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Observations on Nereocystis

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(WITH PLATES 361, 362)

Introductory and Historical.—The bladder-kelp of the northern Pacific coast, first described by Mertens in 1829 under the name of *Fucus Lütkeanus* and afterwards made the type of the genus *Nereocystis* by Postels and Ruprecht, has never received the study that its great size and abundance would have led one to expect. A brief and incomplete account of its anatomy is given by Postels and Ruprecht in their *Illustrationes Algarum*, in which Plate XXXIX., Figs. 24–30 are of the histology of the mature stipe, pneumatocyst and lamina. The most extended anatomical study is that by Oliver in his paper on the *Obliteration of the sieve-tubes in Laminariaceae*, published eleven years ago in the *Annals of Botany*, while some isolated references may be found scattered through the literature of the Laminariaceae and that of West American algae.

I have had the unusual opportunity of examining some hundreds of specimens of *Nereocystis Lütkeana* collected at Puget Sound during 1897 and 1898 by Miss Josephine E. Tilden. The series includes undoubted specimens from one-half of a millimeter in length to eighty feet and serves to illustrate many points of the anatomy and development which have not hitherto been described. Still younger forms carrying the series back close to the germinating spore are probably in the collection but I am not yet prepared

to speak with absolute certainty of any plant under one-half millimeter in length. The reason for this is that the youngest plants, collected in two feet of water off San Juan Island at 10 A. M., June 5, 1898, during the lowest low tide of the year, are mingled with young *Costaria Mertensii*, *Laminaria saccharina* and *Alaria*. It is difficult to distinguish the young stages of Laminariaceae from each other and this difficulty increases inversely with the age of specimens. Yet a careful comparison of sections shows structural peculiarities which enable one to speak with some degree of certainty.

The first published reference to young *Nereocystis* plants and the first descriptions of their fruiting structures are those of Areschoug in a paper in the Swedish journal, Bot. Notiser of 1876, pp. 65–73 and in Observationes Phycologicae. In the first paper Areschoug describes his *Pelagophycus giganteus* under the name of *Nereocystis gigantea*. In this article he describes the young unilaminate plant and explains how the lamina is split vertically and how each half is repeatedly split. He describes the change in shape of the pneumatocyst as it develops and makes some anatomical observations upon the mucilage ducts which are quoted later by Guignard. The resemblance of the young *Nereocystis* plant to young *Laminariae* was apparent to him.

The only previous American reference that I have found to young *Nereocystis* plants—in which, I have been unable to discover any addition to the facts set down by Areschoug thirteen years before—is in one of the more recent papers of Professor W. G. Farlow of Harvard University who, in the Bulletin of the Torrey Botanical Club for 1889, comments upon a series of young plants presented to him by Miss Lennebacker, concerning which, however, I have not learned that he ever published further. The smallest plant he mentions was four inches in length and he states that the "bladders begin to show themselves when the plants are about eight inches long." It is possible, however, by the sense of touch to distinguish the pneumatocyst in material but three centimeters in length and the organ becomes visible as a slight expansion of the stipe shortly after. Professor Farlow, with Areschoug, observed the resemblance of the immature plants to young Laminariaceae of the digitate section, possibly basing his statement

upon Foslie's plates. It is certainly striking and even more so when still younger material is compared. I do not know what precautions Miss Lennebacker took in the selection of her series, but from Professor Farlow's observation that the stipe is slender and *short* I should think that possibly some *Laminaria* sporelings might have been included. My own researches have shown that in *Nereocystis* plants only one millimeter in length the stipe is nearly as long as the lamina while in plants three centimeters long the stipe is five millimeters in length, showing an early, rapid elongation of the lamina.

General Structure.—The general organography of *Nereocystis* may be best explained by describing the plant as made up of two principal areas—a proximal, affixed portion and a distal free portion. At first when the plants are merely elongated pear-shaped bodies less than .1 mm. in length (as probable from the examination of material that I am yet compelled to consider doubtful) the holdfast or proximal portion is spread out as a disc-shaped foot from the under side of which numerous rhizoid-protuberances are affixed to the substratum, while the distal portion enlarging apically is still of a generaliy cylindrical shape. This primitive holdfast or "primitive disc" recalls the similar structure described for young specimens of *Saccorhiza dermatodea* by Professor Setchell and for *Laminaria* by Foslie. As in *Saccorhiza* the primitive disc is provided with a crenate margin which becomes lobed and the lobes develop into protuberances which may be termed the primitive hapteres. Later when the plant is a centimeter or more in height, but sometimes not until four or five times as long, the secondary hapteres begin to show themselves as rows of emergences just above the point where the primitive disc passes over into the distal portion of the plant. These secondary marginal hapteres flatten themselves where they come in contact with the substratum and the whole primitive disc develops into a sucker-shaped cup. Above the first secondary hapteres others commonly develop, the number of emergences in the broken whorls being somewhat variable, but in general each emergence stands over an emergence of the whorl below. In this way, finally, a large hapteric area, the "holdfast," is developed consisting of hundreds of dichotomously branched cylinders and forming a ramose body more than a foot in diameter.

The primitive disc finally stands near the center of the great fixation-organ made up of the hapteres progressively developed from above. If growing upon a flat surface, the ends of the hapteres originating from higher whorls on the stipe stand concentrically outside of those belonging to hapteres of lower whorls and the whole apparatus is to be diagrammed as a series of superposed cones very much flattened and split.

In old material of *Nereocystis* a great many confluent callosities may occur along the stipe. These originate from emergences precisely similar to those which produce hapteric branches and probably the callosities may be regarded as homologous with unattached hapteres. I have not observed dichotomy in any of the callosities nor need I discuss at length their probable function. It suffices to indicate their great similarity of origin to the secondary hapteres, suggesting that the whole stipe is capable of forming holdfast organs from the base to the pneumatocyst. The callosities are sometimes as large as one's finger and spirally disposed around the slender stipe reminding one a very little of a loose growth of *Cuscuta* on the stem of a flowering plant. This position I regard as indicating torsions of growth in the stipe and it has been clearly observed that while the elongated callosities are in some cases confluences, in others they originate from single original hemispherical protuberances. On the stems of young plants a foot or two in length the callosities are extremely rare, but they progressively develop and increase in number and size until old stems are abundantly provided with them along much of their extent. They are particularly in evidence when two or more plants growing close together have twined about each other as they often do. On the stipes of such the callosities are developed as a continuous cushion where the stems are in contact. Although really organs of the stipe, I have mentioned these callosities at this point because of their evident homology with the hapteres.

The distal end of the *Nereocystis* plant finally differentiates itself into three areas, stipe, pneumatocyst and lamina. When very young no distinction between these areas is visible, but in the smallest plants I have seen—and they may possibly be *Costaria*, *Laminaria* or *Alaria* sporelings rather than those of *Nereocystis*—the stipe is marked off by a sharp constriction from the primitive disc and

gradually enlarges distally into a portion which afterwards undergoes a lateral flattening into lamina. The pneumatocyst originates as a swelling in the stipe just below the lamina and is the last of the three distal members to come into existence as such. At first the lamina is single and uncleft, of a rather narrow, lanceolate shape and becoming narrowly ovate with acute tip as it grows older. The first longitudinal slit which separates the lamina into two halves right and left appears near the base of the lamina (according to my series of young forms) when the length of the whole plant has reached about 13 cm. This cleft is the only one which reaches clear to the surface of the pneumatocyst though the second cleft comes very close and divides the two laminae into four. Oliver's statement, no doubt based upon an incorrect figure of Postels and Ruprecht, that as a rule five petioles are borne upon the pneumatocyst is quite unconfirmed by any of the plants which I have examined. On the contrary as pointed out by Areschoug there are but two main distinct laminae each of which is cleft almost to the base by the secondary longitudinal furrows and tertiary and successive furrows cleave these laminae almost to the base, so that a hasty examination suggests the presence of two tufts of leaves. In each tuft there may be twenty-five or more lobes or leaves. The resemblance of the leaf arrangement to that in Areschoug's *Pelagophycus giganteus*, a plant of the Californian coast and by some American students still maintained to be congeneric with *Nereocystis Lütkeana*, is certainly very demonstrable.

The origin of the clefts and of the pneumatocyst is better discussed in the histological portion of my paper but the primitive differentiation of lamina and stipe, since it arises simply by the lateral flattening of a primitive piriform distal bulb, may be noted here. At first the lamina is shorter than the stipe but after the plant has become about a tenth of a millimeter in length the lamina begins to elongate relatively faster for a time, but when the plant has reached a length of twelve or thirteen centimeters the elongation of the stipe becomes relatively more rapid and this ratio continues so that in a plant eighty feet long the stipe measures forty feet, from hapteres to pneumatocyst, and another forty to the tips of the slender ribbon-shaped lobes of the two great leaves. But in longer plants the stipe is proportionately more extended while

the leaves rarely come to exceed fifty feet in length. This measurement of the leaves much exceeds that given by Mertens in his letter to his father published by von Chamisso in the 1829 volume of Linnaea. Mertens gives twenty-seven feet as the extreme leaf-length and Oliver, quoting no doubt from this original account by the discoverer places the leaf-length at eight meters. We have, however, leaves nearer fifteen meters in length than eight. A hundred meters as the extreme length of a mature individual, the figures given by Kjellman in the Engler-Prantl Natürpflanzenfamilien, is not at all excessive. Of this at least eighty meters would belong to the stipe, two or three meters to the elongated retort-shaped pneumatocyst and the remainder to the laminae.

The breadth of mature lobes of the lamina is from 8 to 12 cm., the diameter of the stipe is from 8 mm. to 2 cm. just under the pneumatocyst area, the pneumatocyst is sometimes 15 centimeters in diameter just below the attachment of the lamina and the branches of the haptere-cluster range from 3–5 millimeters in diameter. These measurements are all conservative and larger individuals may no doubt be found.

When first formed the pneumatocyst is spherical and retains this shape in plants 30 cm. long. Later it becomes ovoid and then piriform. In a plant 30 cm. long the pneumatocyst is one centimeter in diameter. In a plant 50 cm. long the pneumatocyst is 2.5 cm. in diameter and 3 cm. in length. After the plant has attained a length of 3 or 4 meters the pneumatocyst begins to elongate and from that stage until maturity maintains the characteristic retort-shaped appearance finally becoming 2 or even 3 meters in length, in which condition, as long ago noted by Mertens, it is employed by the Aleutians to siphon water from their canoes. By the same tribes, Mertens also observed that the stipe is employed for fishing lines. As learned by Miss Tilden such lines are still preserved as curiosities by a few native fisher-women, but ordinary tackle is generally in use.

Reproductive Area.—The only functional reproductive bodies known to occur in *Nereocystis* are the spores, formed in sporangia. Together with the paraphyses these sporangia produce large soral patches on both sides of the leaf. A sorus may be as much as a meter in length, from 3–7 cm. in width, and on a single leaf three

or four such sori may occur, their ends separated by but a few centimeters of sterile tissue. The leaves which bear the sori are rather broader than the sterile leaves. Fruiting patches are very conspicuous on account of their slightly lighter color than the sterile tissues. Oliver writing in 1887 states categorically that nothing is known of the reproduction of *Nereocystis*, but Areschoug in 1876 observed the sporangia and paraphyses together with some young forms, as indicated in his paper in Bot. Notiser, and afterwards in 1884 returned to the subject in his *Observationes Phycologicae* where a brief systematic description is given. My own researches have cleared up the origin of the sporangia and paraphyses and I have been able to follow the development of the sorus from its first inception.

Ecology.—The habit of mature *Nereocystis* plants is to attach themselves in channels where the tides are swift and beds of the plant are to be looked for in tide-ways. I think that plants which are adapted to life in strong tide-ways and tide-rips should be distinguished as a special ecological sub-class of hydrophytes distinct from such plants as *Fontinalis* which grow in river-channels and may be termed *rheophytes*. Previously I have noted the adaptation of certain limnetic plants to withstand the impact of surf and proposed for them the name of *cumaphytes*. I now venture to suggest that plants like *Nereocystis* or *Alaria* be regarded as typical of the tide-way habitat and be known as *palirheophytes*. When the tide is not running the pneumatocysts float more nearly perpendicular and show as round bulbs at the surface of the sea, but when the tide begins to run tension is exerted on the stipe and holdfast and the long retort-shaped pneumatocysts lie lengthwise with the current. The leaves are always somewhat submerged; especially is this true when the tide is running—a habit which protects their more delicate bodies from the destructive friction and impact of the surface. When the tide changes the shifting of the great pneumatocysts is sufficient in force to overturn small skiffs which may be caught among them. But larger boats find a *Nereocystis* bed a safe anchorage if a storm overtakes them while near the rocks of a leeshore, and Puget Sound fishermen often anchor their boats to a dozen of the *Nereocystis* pneumatocysts and have no fear of being blown upon the rocks, so firmly are the

hapteres attached to the bottom and so strong are the stipes. In the late autumn the *Nereocystis* dies, for, as long ago noted by Mertens, while one of the largest of the algae it is an annual.

Histology.—The intimate structure of the Laminariaceae has commanded the attention of many careful observers. Among the more important papers that I have consulted may be mentioned those of Postels and Ruprecht (1840), Ruprecht (1848), Thuret (1850), Le Jolis (1855), Agardh (1868 and 1873), Reinke (1875), Janczewski (1875), Areschoug (1876), Foslie (1884), Will (1884), Wille (1885, 1897), Kjellman (1883, 1893), Grabendörfer (1885), Oliver (1887), Rosenthal (1890), Setchell (1891), Guignard (1892), Murray (1893). Few of these make any mention of *Nereocystis*, but since in details of structure the genera of the Laminariaceae are rather similar, all these papers and several others have been of assistance.

In general, as particularly demonstrated by Reinke and Wille, the Laminariaceae have well-marked tissue-areas which may be regarded as in a degree physiologically equivalent to those of higher plants. Cortex and central cylinder are distinguishable in stipes and laminae. Mestome, stereome, tegumentary and photosynthetic areas are well differentiated although the second, to which Setchell's sclerenchyma of *Saccorhiza* may belong, is poorly developed as in most hydrophytes.

The primitive Disc.—Longitudinal sections of a primitive disc belonging to a plant 18 mm. in length showed it to be irregularly circular in shape, .8 mm. in diameter, .1 mm. high. Near the center of the upper side arises the stipe with a diameter of 75 mic. The primitive disc consists of parenchymatous tissue of approximately isodiametrical polyedral thin-walled cells about 12 mic. in diameter. The superficial layer is made up of much smaller epidermal cells similar to those which occur over the stipe and lamina. The layer of cells which is appressed to the substratum—in this case the surface of a *Zostera* leaf—are for the most part similar in shape to the general fundamental tissue of the disc but not much more than half as large. Some of these appressed cells are prolonged into stocking-shaped rhizoids the flat surfaces of which lie very close against the epidermis of the eel-grass. Measurements of some of these stocking-cells showed them to be 7 mic. in diam-

eter, the leg and foot of the stocking each being 15 mic. in length. Just above the area of affixation numerous transverse partitions are visible in the fundamental tissue of the disc and apparently there is here a layer somewhat similar to the cambial zone of higher plants and by it the primitive disc becomes thicker. At the same time divisions in various planes cross the more internal cells of the fundamental tissue and the epidermal cells increase in number by vertical divisions. As elsewhere in the plant the epidermal layer of the primitive disc is abundantly provided with chromatophores, which in my aniline-water-safranin preparations are stained deeply, while the fundamental tissue cells are given a pink hue by the staining of their thin walls. At this age the margin of the primitive disc has not yet become crenate, although the slight irregularities of its circular form will in older material bring about the crenations of the margin which eventually protrude themselves as the primitive hapteres. While the primitive disc is in the condition just described, the medulla of the stipe is sharply distinguished from the cortex by its longer and narrower cells, but the differentiation of sieve-tubes and pith-web has not yet taken place. Rather is the whole area of the stipe made up of prosenchymatous prismatic cells without intercellular spaces and the cortex consists of cells quite similar but considerably shorter. I am not able to distinguish any differences between the epidermal cells of different parts of the plant in this stage of its growth.

Origin of the secondary Hapteres.—Longitudinal sections through the stipe of a plant 12 cm. in length just above the primitive disc which has now increased in diameter to 5 mm., show the origin of the first secondary hapteres. I am not able to make a distinction between a rhizogenous area of the stipe and the rest of that organ, for as has been previously said, callosities which I consider equivalent to secondary hapteres may, under favorable conditions, be produced all the way up the stipe to the pneumatocyst. Those hemispherical emergences of the cortex which are produced close to the primitive disc develop as hapteric branches. The first appearance of the hapteres is as a slight swelling of the cortex and it will be found that this swelling is due to the more active divisions of a cambial layer lying between the central cylinder, now very distinct, and the epidermis. Soon this swelling becomes

hemispherical and now the cells of its central portion are elongated in a direction parallel with the axis of the emergence. There is not any definite development of a central cylinder in the haptere, but the whole organ is made up of thin-walled somewhat prosenchymatous cells, covered with the characteristic epidermis, just below which the cells are short and flattened and in a state of rapid division concentrically with the surface of the emergence. In the hemispherical stage of the secondary haptere the central cells lying near the base of the emergence are many of them 150 mic. in length by 45 mic. in breadth, while the cambial cells three or four layers underneath the epidermis are 10 mic. in length and 15 mic. in breadth.

Dichotomy of the secondary Hapteres.—The primary hapteres do not commonly show dichotomy, but remain as crenations of the disc-margin. As the disc enlarges these crenations sometimes become indented and this indentation is equivalent to the sharp characteristic dichotomy of the secondary hapteres. In the latter after the first emergence has elongated into a cylinder with rounded end, the densely protoplasmic character of the apical region where the cambial cells, or meristem, is located, gives a darker appearance to the apex of the haptere. Gradually this apex becomes laterally compressed and an indentation appears at the summit separating two meristematic areas. Longitudinal sections through such apical areas show that the meristem of the exact apex ceases its active concentric divisions, while right and left of this region the divisions continue, thus forming two new apical cones, which continue to develop as before. Forking of the haptere originating in this manner may be repeated a number of times, and thus the much-branched later hapteres of the plant are developed. The cambial zone of the apex extends down the sides of the hapteric branch and is utilized in the progressive thickening of the organ. The haptere may then be regarded as a conic-cylindrical organ surrounded by an epidermal layer concentrically underneath which is a general cambial zone. By the division of the apical region of this zone the haptere increases in length; by longitudinal divisions in the lateral portions of the zone the haptere increases in thickness. Even in the most mature hapteric branches the lateral cambium is still visible as such and I have not been able to dis-

cover that the growth in thickness is definitely terminated except by the cold of the autumn, when the growth of the whole plant ceases and later the individual perishes.

Fixation of the Haptere.—If the end of an hapteric branch comes in contact with the surface of a rock or other object which gives the necessary resistance, a fixation-area is developed. The epidermal cells of the tip lose their chromatophores and the layers just within remain small but thicken their walls. The general shape of the cell-cavities throughout the fixation-area remains very similar to that of the cambial cells from which they were developed. Growth in length is now terminated, but growth in thickness continues. Sometimes one haptere affixes itself to a neighboring haptere, in which case the ordinary fixation-area arises precisely as if the organ had been affixed to a rock, but this obviously cannot be a common occurrence; yet in every holdfast that is fully developed several such fixations of one haptere to another are likely to be met with.

Callosities of the Stipe.—The characteristic verrucose confluent or elongated callosities of the stipe originate from emergences precisely similar to those which in the holdfast region produce the hapteric branches. I have not observed dichotomy in these callosities, nor do their surfaces become modified into definite fixation-areas. Where two long stipes of adjacent plants have become entwined as frequently happens, the callosities are well developed all along the area of contact. Their structure is altogether equivalent to that of the hapteric branches, and as previously noted, I consider them homologous with hapteres. They may be regarded as cushions to prevent abrasion when two or more stipes have become intertwined.

Structure of the mature Haptere.—When full-grown the haptere consists of but four readily distinguishable tissue areas, the epidermis, the lateral cambium, the rather thick-walled fundamental tissue, and the fixation-area. Chromatophores are not so abundant nor deeply stained in the epidermis as in the same layer of the pneumatocyst or laminae, hence the hapteric region is of a much lighter green than the portions of the plant exposed to stronger illumination. The same is true of the epidermal region on the lower portion of the stipe. The cambial area in the mature hap-

tere is still definitely differentiated as such and consists of the characteristic flattened cells with thinner walls than those of the fundamental tissue. The central fundamental tissue making up the great bulk of the organ is composed of rather thick-walled approximately isodiametrical parenchyma. The fixation-area consists of much smaller thick-walled cells shaped like those of the cambium.

Structure of Stipe.—In a young plant 18 mm. in length the stipe was .25 mm. in diameter midway between the primitive disc and the laminar expansion. Cross sections and vertical sections showed a central cylinder .08 mm. in diameter already sharply differentiated. It could be recognized in cross section by the smaller diameter of the cells and in longitudinal section by the greater comparative length. All the cells, however, within the clearly marked epidermal layer could be described as thin-walled parenchyma or prosenchyma. In material of this age mucilage-ducts were not seen, nor had the intercellular spaces of the pith-web begun to originate. The whole stipe was solid and approximately homogeneous. The cells throughout were strongly stained and many of the nuclei showed sharp and distinct mitotic figures.

In slightly older material than that just described the first intercellular spaces begin to appear as clefts between the lateral walls of the central pith cells, and a little later the layer of cells immediately surrounding the primitive pith develops the first sieve tubes, while at the same time the cortex rapidly increases in thickness. In a plant 12 cm. in length the stipe was 1 mm. in diameter and the central cylinder measured .25 mm. across. In this stage the pith-web made up of loose, anastomosing, branching, septate filaments is well established. The filaments of the pith-web at this time measured about 10 mic. in diameter. Between the meshes of the loose network an abundance of slime was present. At the periphery of the pith-web lay the "sieve-tubes," as they have been termed, the development of which from ordinary cortical cells was not difficult to follow. Most of the centrally disposed sieve-tubes appeared very much smaller and thicker walled in the cross section than did the peripheral elements. This was due to the longitudinal stretching of the inner and older tubes. In most of the cross sections through this material the

sieve-tubes stood in radiating lines of three or four to each group. Although the trumpet-hyphae, reserving this term for the sieve-tube-like elements of the pith-web in contradistinction to those developed from the cortex, were not yet apparent in my 12 cm. material there were some perforated transverse walls visible in the ordinary anastomosing filaments of the web. Although my stains have not been nuclear some excellent mitotic figures were visible in this preparation.

Longitudinal sections through the 12 cm. material show the cortex to consist in general of thin-walled parenchymatous tissue made up of cells about twice as long as broad in the layers close to the epidermis but becoming progressively longer and slenderer towards the central cylinder, until those cells bounding the pith-web become transformed into the sieve-tubes. The pith-web cells are attached to the sieve-tube cells and to the undifferentiated layers just outside of the sieve-tube zone. The young sieve-tube is indistinguishable from an ordinary prosenchymatous cell of the inner cortex. The nuclei of some inner cortex cells undergo fragmentation and then these cells are greatly elongated as the stipe grows in length. As one elongates it becomes much narrower, so that while the diameter of the cell from which a sieve-tube originates may be 12 mic. and the length 80 mic. the diameter of the sieve-tube which arises from it may in its thinnest portion be scarcely more than 1 mic. while the length may exceed a millimeter! Cross sections through the slenderest part of such a sieve-tube show its wall to be thickened like a thermometer tube, while the cell contents, deeply stainable with aniline blue, fill the extremely delicate capillary cavity.

Observation of a series of longitudinal sections makes it seem probable that the first sieve-tubes formed, and many of the successive tubes, are elongated to such tenuity that they finally pull apart in the middle and then the free ends of the tube deliquesce into the common gelatinous slime of the pith-web leaving only the thickened so-called callus patches attached to the remnants of the tube and even these may disappear. The centrifugal production of sieve-tubes continues vigorously while the stipe is young, but in old material not so large a number proportionately are to be found. The stretching of the sieve-tube has all the appearance of a passive

extension of the cell, while cross partitions are still being formed in the cortical region outside of the sieve-tube area. I believe that the fragmentation of the nucleus preventing the regular development of cross partitions in the mother-cell of the sieve-tube is the occasion of its failure to divide further and of its consequent passive elongation.

It was in this 12 cm. material that the best examples of cryptostomata were discovered. I shall return to their discussion later while considering the lamina. It suffices to mention at this point that these peculiar piliferous organs of doubtful morphological significance are present upon young stipe as well as upon young lamina, but in mature plants I have not seen them.

Origin of the Pneumatocyst.—A continuous ribbon of 3 mic. sections was taken across the area of the pneumatocyst. The series begins in definite stipe area, traverses the pneumatocyst and ends in the base of the lamina. The plant measured 12 cm. in length. In the undoubted stipe area the pith-web is seen to have its meshes filled with gelatine and the first appearance of the pneumatocyst is a small rift in the jelly near the center of the pith-web. As the series passes over through the pneumatocyst this first rift is seen to increase in size and others appear near it. At the same time a distinct flattening of the stipe takes place and it is worth noting that the primitive pneumatocyst is clearly elliptical in cross section rather than spherical. As the series continues across the pneumatocyst area rifts in the jelly of the pith network become smaller. The flattening of the whole area becomes more marked and in the base of the lamina the section has become five or six times as long as it is broad and shows the undoubted lamina characters. The pneumatocyst, stipe and lamina are essentially the same in structure, but the bubble which forms in the pith-web of the pneumatocyst area increases very rapidly in size and the vesicle thus formed becomes finally the greater retort-shaped organ of the mature plant.

Structure of older Stipes.—As the plant increases in size the stipe continues to thicken by concentric walls which appear in several of the sub-epidermal layers of the cortex. A plant 12 dm. in length showed a stipe 5 mm. in diameter of which the central cylinder occupied 1.5 mm. In material of this age the cortical

cells have not yet developed the characteristically thick walls of mature stages, but mucilage canals are now in evidence, a circle of them appearing subepidermally. I am able to confirm Will's and Guignard's account of their development. They originate by vertical radial partitions of certain cortical cells in the cambium region. Just outside of the two cells thus formed a cleft appears and this cleft increases in size while the two small cells within divide by other vertical and transverse partitions finally coming to line the half of the canal which faces the central cylinder. These small cells are the secretion-cells. They do not persist but after a time break down so that in mature portions of the stipe the mucilage-duct in cross section appears merely as a circular-outlined intercellular space.

It is in material of the same age or younger that one finds well-developed trumpet-hyphae intermingled with the ordinary anastomosing filaments of the pith-web. While these cells do not become nearly so attenuated as the sieve-tubes, they are nevertheless slenderer and three or four times as long as the ordinary cells of the pith-web. Their ends, where two come in contact, are much swollen. I have not been able to discover whether fragmentation of the nucleus precedes the formation of a trumpet-hypha as it does that of the sieve-tube. Neither my Russow's callus reagent nor corallin-soda gave results such as those which Oliver obtained, nor have I been able by microchemical methods to demonstrate the presence of true callus, such as has been announced for the sieve-tubes. This is possibly owing to the preservatives which have been applied to the tissues, or their age, but I am inclined to accept rather the views of Wille regarding the callus than those of Oliver. No evidence of protoplasmic connections between adjacent sieve-tubes or trumpet-hyphae has been obtained. At this point it is well to state definitely that the material I have examined seems to show clearly that there are two very different kinds of tubular cells with perforated end partitions. Wille, in criticising the results of Oliver, who made a distinction between trumpet-hyphae and sieve-tubes, seems to suggest that there is only one category of such cells and that differences are of degree and not of kind. According to my observations the trumpet-hypha does not become extremely attenuated nor does it

develop the thermometer-tube cell with capillary lumen such as characterizes the sieve-tube. Since the morphological position of the two kinds of cells in the stipe is different, since their origin is different, and on account of their very easily distinguishable structure, I can but follow Oliver and maintain them as separate structural elements not to be confused on account of their similar perforated end-plates. They are abundant in older material but the relative proportion of the two varieties of cells changes. While in young material an abundance of sieve-tubes is characteristic, in old material the trumpet-hyphae are abundant and but few sieve-tubes remain, most of them having undergone extreme attenuation and subsequent degeneration.

Structure of mature Stipe.—Cross sections through the stipe of a plant 25 meters in length showed its diameter to be 10 mm., of which the central cylinder comprised 2.5 mm. In this material the cambium zone lying four or five layers within the epidermis is still distinct. Numerous mucilage canals are present, most of them lying in the concentric circle first developed and now separated from the periphery of the stipe by numerous layers of cortex developed after their formation from the cambium. The average size of cortical cells in cross section is about 25 mic. Their walls, however, are now distinctly thicker than at first and at the angles between the cells the thickening is sometimes increased giving to the tissue a collenchymatous appearance. By the thickening of the walls great elasticity and strength is given to the stipe. Intermingled with the large cortical cells are many smaller ones averaging 10 mic. in diameter. The central cylinder in the mature stipe consists of a loose pith-web of anastomosing filaments, imbedded in gelatine, among which abundant large trumpet-hyphae are apparent. Many of the trumpet-hyphae connect by lateral processes with the ordinary filaments which are not more than half as great in diameter. In material of this age the sieve-tubes are very difficult to find, almost all of them having been destroyed. This is not what Oliver means by his phrase "obliteration of sieve-tubes" for he applied that term to the closing of the plates by his callus-like substance, nor can I learn that the fact has previously been recorded. Oliver mentions that the true sieve-tubes are abundantly branched. In my opinion this is a mistake. Anastomoses

occur between sieve-tubes and the formative layer of the cortex from which they arise, but I have seen no true anastomoses between the sieve-tubes and the hyphae of the pith-web, nor have I observed any branching of the sieve-tubes by the formation of lateral emergences such as are so common in the trumpet-hyphae. The great abundance of the trumpet-hyphae and their peripheral position, as well as central, in the pith-web may easily have given rise to a misconception.

Structure of the Pneumatocyst Wall.—Sections of a pneumatocyst wall taken from a plant 12 dm. in length in which the pneumatocyst was approximately spherical and 4 cm. in diameter showed the wall of the cyst to be 4.5 mm. thick. The epidermis is not essentially different from other epidermal tissue and in the subepidermal regions a cambial layer is present by divisions of which the wall is thickened. The older cortical cells throughout the pneumatocyst wall have their long diameters parallel with the radii of the organ, until an inner cambial zone is reached close to the cavity of the cyst. Here the cells become tabellar in form with their long axes parallel with the surface. The pith-web is altogether destroyed, but in this material characteristic elongated sieve tubes with narrow lumina are present. The presence of such an inner cambial zone seems to be peculiar to the pneumatocyst area and in this zone numerous transverse as well as concentric walls are constantly being formed. The intermediate area between the inner and outer cambium, as the pneumatocyst matures into the retort-shaped body, finally comes to consist of cells elongated in the axis of growth rather than as at first perpendicular to this axis.

Structure of the young Lamina.—The basal structure of the lamina is identical with that of the stipe. Like the latter it must be considered to consist of central cylinder—in this case a very thin plate of cells—of cortex and of epidermis. My serial sections through stipe, pneumatocyst and young lamina show the progressive change from the cylindrical through the oval and elongated-oval to the thin ribbon-shaped section and enable the homologies of the various areas of the lamina and stipe to be exactly determined. Cross sections through the lamina of a plant 18 mm. in height showed the thickness of the lamina to be a little over .1 mm. while from edge to edge the lamina measured 4 mm. The most marked dif-

ference between young lamina and stipe is the early development in the former of mucilage canals which lie in rows just within the epidermis. The cortex in this stage consists of about two layers of cells, those just under the epidermis being generally larger than the ones which abut upon the plate of cells regarded here as central cylinder. The secretion cells of mucilage ducts in this material seem to line the canal not only along the inner side but along the outer as well. They stain deeply with aniline-water-safranin. The cells of the central plate are narrow, much thicker-walled than those of the pith-web in the stipe and packed together in such a way as to leave only very small intercellular spaces. Many of them run crosswise of the leaf while others run lengthwise. The result of this is to make this area not dissimilar to the same area in longitudinal section, but as the leaf matures the pith-web character of the middle lamella becomes more marked and trumpet-hyphae are present in longitudinal sections of the lamina of a 12 cm. plant. In a leaf of this size the cortex consists of five or six layers of cells, the inner larger than the outer, but along the middle lamella the cortical cells are smaller and elongated in the axis of the leaf. Where they abut on the middle lamella they pass over into the character of pith-web tissue. By the time the leaf has acquired this size the secretion-cells of the mucilage ducts have for the most part broken down and cryptostomata have developed in the furrows which lay over the mucilage ducts of the younger leaf. The epidermal cells in young leaves are about three times as broad as they are high, are densely protoplasmic and stain vividly. Interesting rows of short cylindrical cells are found in the pith-web, their diameter sometimes exceeding their height. Such cells finally become elongated into the ordinary hyphae of the web. Cross sections of the leaf of a 12 centimeter plant show some sieve-tubes still present and more abundant in the growing region of the leaf which is essentially basal.

Towards the tip of the leaf the lamina is thinner in the 12 cm. material, the epidermal cells are more nearly square in outline, the cortical cells are very large and approximately isodiametrical, while the central lamella is reduced to about two layers of thick-walled cells of elongated shape with few intercellular spaces. From this region mucilage ducts and sieve-tubes are absent for it was formed

before the time of their differentiation, nor are cryptostomata abundant toward the tip of the leaf.

Splitting of the Lamina.—From a series of sections taken through young laminae of a plant in which the first cleft is beginning to appear I have been able to determine the origin and occasion of the cleft. In *Nereocystis* the cleft does not appear to be of the nature of a wound as said by Professor Setchell of the similar phenomenon in *Saccorhiza dermatodea*, but it seems to take place in this way: A single row of cortical cells immediately below the epidermis deliquesces or collapses and the epidermis furrows along the depression. The deliquescence is propagated to adjacent cells right and left of the furrow and continues down to the middle lamella. This furrowing may take place along one surface of the leaf or along both surfaces until the epidermal cells come to lie against the middle lamella. The latter then breaks down and the two epidermises at the bases of the furrows are contiguous. The split takes place along the base of the furrow and leaves the two halves of the lamina with apparently normal unwounded edges. In some cases the cortex cells come down together over the edge of the deliquescing central lamina so that it is extremely difficult to distinguish between the original edge of the lamina and the edge of the cleft. The epidermis suffers no disintegration during the process. The actual cleavage of the lamina may be due, as Professor Setchell suggests for *Saccorhiza*, purely to the impact of the waves upon the weakened structure, but it may also be due to a definite separation of the epidermal cells from each other by a chemical change in their walls. The furrow of the epidermis seems to deepen, destroying the inner cells of the lamina as it progresses. The split takes place first in the more complex basal portion of the leaf and is perpetuated to the tip. I have not been able to determine whether the cleft is propagated in this manner clear to the simpler primitive-tip end of the leaf, or whether it becomes a mechanical cleft of the nature of a wound when it reaches the distal end of the lamina.

No evidence has been secured to indicate that there is any renovation of the lamina in *Nereocystis* such as is well known to take place in some of the Laminariaceae.

Structure of the Cryptostomata.—The organs of the young stipe

and lamina which are with some hesitation termed cryptostomata appear as short, irregular furrows from the surface of which tufts of two- or three-celled hairs are produced. They are not so conspicuous in *Nereocystis* material that I have examined as those of *Adenocystis*, *Alaria* and *Saccorhiza* described by Kjellman and Murray. I have failed to find them save on young plants less than half a meter in height. Various suggestions have been made by different students of the Phaeophyceae regarding their significance. By some they are regarded as vestigial reproductive tracts, but it will be unnecessary to go into this further than to make the suggestion that the areas classed as cryptostomata in different genera of brown algae are not by any means necessarily to be considered as everywhere the same. Indeed it is quite clear that in the Splachnidiaceae and Laminariaceae they are probably of different significance from those of Fucaceae. They stain deeply with aniline dyes in *Nereocystis* and I suspect from this fact that I have not seen mature stages of the hairs. There is a possibility that the mucilage canals are invaginated furrows and that the so-called cryptostomata are developmental stages of these, but I have not satisfied myself upon this point.

Primitive Furrows of the Lamina.—An interesting character which is to be noted in very young plants is a longitudinal furrowing of the lamina by parallel grooves which occur on both sides, each groove lying over a mucilage canal. In the primitive tip where mucilage canals are absent the furrows also are absent and leaves two or three centimeters in length have lost these furrows as may be seen in cross section, but in plants 1–2 cm. in height a deep furrow lies over each longitudinal mucilage canal just within the epidermis. Something of an appearance similar to that of young *Costaria* plants is given by these longitudinal furrows. But in *Costaria* the striation of the lamina arises, as shown by cross sections, from ridges which structurally belong to the cortex and over which the epidermis is elevated by the growth of inner portions of the lamina. Nor in *Costaria* do the ridges bear the same relation to mucilage ducts that is borne by the primitive furrows in the *Nereocystis* sporeling. Indeed I have not observed mucilage ducts in young *Costaria* laminae.

Origin of Secretion-cells in the Lamina.—It has already been

noted that the secretion-cells seem to line all sides of the mucilage duct in young lamina while in young stipe they occur only on the side of the duct which is toward the central cylinder. The occasion for this seems to be explained by some of my sections which show the first division-wall of the primitive secretion-cell parallel with the face of the lamina instead of perpendicular to the surface as in the stipe. The cleft then arises between these two small cells, one lying peripherally and one centrally. But in the stipe the first cleft appears in a plane perpendicular to the surface and not between the two primitive secretion-cells, but between the cells just peripheral to them. I do not like to speak with positiveness upon this point since it is at variance with the results of previous investigations upon other genera, and but a few of my sections are helpful.

Growth of the Lamina in Length and Thickness.—As in other Laminariaceae each lamina of *Nereocystis* grows by a generally basal area which lengthens in both directions, so that the elongation of the lamina is neither strictly basipetal or acropetal. The thickening of the lamina, which finally, in old leaves, comes to consist of from five to ten cortical layers on each side of the central lamella which is itself made up of a rather compact pith-web tissue eight or more layers across, goes on in the general basal area of growth. Old laminae are of a mature type of structure from base to tip since the original thinner primitive tip area has been worn away by the action of the waves and the disappearance of the primitive tip is often to be noted even in very young plants less than 12 cm. in length.

Origin of the Sorus.—The sorus of *Nereocystis* in its structure and origin is altogether typical of the family. The first evidence of the sorus is marked by transverse divisions in the epidermal cells parallel to the surface of the lamina. In this way a double layer of somewhat larger deeper-stained superficial cells and smaller cubical more dimly-stained sub-epidermal cells comes into existence. The superficial cells elongate into the club-shaped paraphyses which finally come to be 30–40 mic. in length, about 7 mic. in diameter at the capitate tip and 2 mic. or even less where they join the basal cells. The sporangium originates as an hemispherical bud on the basal cell beside the paraphysis. By the attenuation

of the paraphyses as they elongate space is afforded the sporangia for their development. In half-mature sori in which the paraphyses were 20 mic. in height the sporangia could be seen as ellipsoid cells about half as long and of quite different shape from the already club-shaped paraphyseal cells. In mature sori, however, when the spores have been formed in the sporangia the difference in the height of the two cells is not so great and the paraphyses overtop the sporangia by but about 10 mic. or even less. The distal end wall of the paraphyses is thickened as in other genera of the same subdivision of the family.

Free zoöspores have not been seen but sporangia ready to open have been found and the spores appear as hyaline cells close to 1 mic. in the short diameter and a very little longer transverse to this. The sporangia doubtless open at the tip to discharge the hundred or more spores contained in each. The end wall of the sporangium, like that of the paraphysis is often considerably thickened. I am able to confirm upon *Nereocystis* material the results of Thuret who noted in 1850 the separation of a thin cuticular pellicle from the surface of sori in *Scytosiphon*, *Laminaria* and some Fucaceae. This pellicle retains the partition-markings of the original epidermal cells quite as figured by Thuret for *Laminaria saccharina* and *Scytosiphon lomentarius*. The exact manner in which this pellicle is separated does not yet appear to be clearly understood, nor am I able to say more about it at this time than that the wall of the soral surface when young seems to be lamellose and the separation of the cuticular pellicle seems to take place by the dissolving of one of the lamellae. Before the separation a few very small bodies, red-stained in aniline-safranin preparations are seen lying against the inner face of the distal wall of each paraphysis. It is possible that they assist in the secretion of the thick pellicle which is finally sloughed off. Sometimes two transverse divisions precede the formation of the paraphysis in which case two layers of floor-cells are produced in the sorus. One or two jointed paraphyses have been seen. The paraphysis seems never to consist of more than two cells and the two-celled condition is extremely rare.

I am under obligation to Miss Josephine E. Tilden for putting at my disposal an abundance of carefully preserved material and

to Mr. Harold Lyon for assistance in the tedious routine of microtomy. The drawings were made by Miss Tilden under my direction.

Explanation of Plates.

Plate 361

Fig. 1. Plant .1 mm. in length. Shows primary differentiation of holdfast and stipe-laminar region. Enlarged.

Fig. 2. Plant 1 mm. in length. Stipe is already elongated. Tip of lamina is removed. Enlarged.

Fig. 3. Three young plants, each one-half natural size. The smallest was 6 mm. in length, the next 18 mm. and the largest 4.5 cm. These plants show the early rapid enlargement of the laminar area.

Fig. 4. A plant 14 cm. in length, reduced one-half, showing the origin of the first cleft near the base. The stipe is proportionally undergoing more rapid elongation in this stage

Fig. 5. Pneumatocyst and laminar bases from a plant 50 cm. in length. Reduced one-half. Showing how only the first cleft reaches the surface of the pneumatocyst.

Fig. 6. Vertical section of primary fixation-area, showing rhizoid cells. From plant 18 mm. long. × 335.

Fig. 7. Diagrammatic cross section of stipe. Sieve-tubes represented as dots. Plant 12 cm. in length. × 25.

Fig. 8. Diagrammatic cross section through pneumatocyst of plant 12 cm. in length. Black spaces in central cylinder represent clefts in the gelatinous matrix. × 25.

Fig. 9. Diagrammatic cross section through base of primary lamina. Plant 12 cm. in length. × 25.

Fig. 10. Cross section through pneumatocyst of 12 cm. plant. Peripheral region. × 335.

Fig. 11. Cross-section through pneumatocyst of 12 cm. plant. Sieve-tube region. × 335.

Fig. 12. Diagrammatic cross section of lamina in 18 mm. plant. Mucilage ducts and grooves are indicated × 25.

Fig. 13. Detail of laminar structure. Cross-section 25 mm. above the top of the pneumatocyst in 12 cm. plant. × 335.

Plate 362

Fig. 14. Cross section through base of lamina in 12 cm. plant showing groove which initiates the longitudinal division of the laminae. 25 mm. above top of pneumatocyst. × 335.

Fig. 15. Cryptostomatal area. Cross section immediately above pneumatocyst of plant 12 cm. in length.

Fig. 16. Sieve-tube from stipe. 12 cm. plant. Shows the fragmented nuclei in the capillary cavity of the cell. × 335.

Fig. 17. Trumpet-hypha from pith-web of plant 12 dm. in length. Shows gelatinous thickening of inner wall. × 335.

Fig. 18. Origin of sieve-tubes. Longitudinal section through area bounding the pith-web. Plant 12 cm. long. Cells to the left with several nuclei become passively elongated into the sieve-tubes. × 335.

Fig. 19. Cross section of mucilage duct in the lamina. Section made immediately above pneumatocyst. Plant 12 cm. long. × 335. Should be compared with Fig. 15 and indicates a possible relation between the structures classed as cryptostomata and the mucilage ducts.

Fig. 20. Cross section of old mucilage duct in stipe. Plant 12 cm. long. Secretion-cells not shown. × 335.

Fig. 21. Cross section of pneumatocyst wall. Mucilage duct in center. × 335.

Fig. 22. Origin of paraphyses in sorus. Mature plant. × 335.

Fig. 23. Origin of sporangia in sorus. Mature plant. × 521.

Fig. 24. Cross section through mature sorus showing paraphyses and sporangia. In the latter spores are indicated. × 335.

Studies in Sisyrinchium, II:—Four new Species from Michigan.

By Eugene P. Bicknell

As represented in Michigan the genus *Sisyrinchium* presents some altogether unexpected features. As many as eight species occur in the state, that is to say, eight species are included among several small collections of Michigan Blue-eyed Grasses which have been sent to me; it is quite probable that the actual number of species belonging to the state flora is even in excess of this. Two of the species are the now well known *S. angustifolium* and *S. graminoides*, common in the eastern states; two are long discredited species which must be restored to good standing—the *S. mucronatum* of Michaux, described in 1803, and the *S. albidum* of Rafinesque, published in 1832; about these I shall have more to say on another occasion; the remaining four species are here described.

It does not yet appear which are the prevailing species in the state. *S. graminoides* seems to have been the most frequently collected, occurring both north and south, but it is apparently quite wanting in certain sections. *S. albidum*, which is common further south, seems to prevail in the southern part of the state, where it has been collected by Professor Wheeler, Mr. Farwell and the Misses Camp; Mr. Farwell has also obtained it in Keeweenaw County in the extreme north. *S. angustifolium*, common eastward, and also to the north and west, appears to occur only sparingly. The four new species must be regarded for the present as rare, each having been collected only at a single station.

Sisyrinchium hastile,

Very slender and rigidly erect, apparently little if at all tufted, 30–40 cm. high, dull green becoming brownish in drying. Leaves very narrow and stiff, thickened, 1 mm. or less wide but becoming over 30 cm. long, tapering into a very slender, obtusely pointed, sometimes terete apex, very closely striate-nerved, granulose-roughened throughout with minute whitish points, except the broadened and membranous sheathing base; stems resembling the leaves, equally slender and granulose, rigid and very straight, or

sometimes twisted and undulate, strongly striate, not at all winged but subterete and bluntly two-edged or obscurely margined: spathes in a conjugate pair at the top of the stem, or sometimes solitary, the outer one stoutly short-stipitate within the base of the common outer bract, each spathe consisting of two opposite pairs of closely imbricated bracts 2–3 cm. long which are attenuate-lanceolate, stiff-membranous and striate, with hyaline margins, the inner pair tapering into weak white-scarious acuminations, all glabrous or the outermost obscurely roughened, the common outer bract very slenderly prolonged for half its length and surpassing the inner ones 1–5 cm.; interior scales ample, sometimes slightly exserted, the larger ones even appearing like inferior bracts: flowers apparently only 1–3 in each spathe, on erect, scarcely exserted pedicels 1.5–2.3 cm. long, mature flower not seen; a dried and brown bud from within a spathe showed unusually long and narrow anthers (4.5 mm. long) cleft for the insertion of the short, partly free filaments, and slender styles about 2 mm. long not, however, surpassing the stamens: young capsule obovate-oblong, dark, rugulose.

Described from a few imperfect specimens communicated by Mr. O. A. Farwell, who collected them June 6, 1896, on "sandy shores of Belle Isle, in the Detroit River, Michigan."

A remarkable plant not closely related to any of our species, but showing a number of striking peculiarities and even possessing claims to generic distinction.

Sisyrinchium Farwellii

Thinly tufted from a cluster of very slender wiry roots which are dark and finely striate when dried, the bases of the tufts sheathed with a coating of coarse dull-brown fibers. Leaves and stems rather light dull-green and slightly glaucescent, not blackening in drying, the spathes paler yellowish-green: leaves apparently not more than half the height of the stem, becoming 3 mm. wide, firm in texture though rather thin and membranous, finely nerved, attenuate-acute, the edges smooth or serrulate: stems flexuous-erect, 20–30 cm. high, 1–2 mm. wide, the wings thin and finely nerved, minutely aculeolate-serrulate or sometimes smooth below; bracteal leaf shorter than the two or three peduncles, slenderly attenuate, below rather abruptly broadened and loosely clasping, the membranous sheathing base striate-nerved, the keel sometimes very rough-serrulate, stem sometimes bearing two rather distant nodes each with its leaf and peduncles: peduncles 4–11 cm. long, somewhat curved, approximate, very slender, mostly less than .5 mm. wide, narrowly thin-margined, smooth to ciliolate-

serrulate, sometimes serrulate only on one side: spathes narrow but abruptly broader than the peduncles, erect or slightly bent, 17–20 mm. long, bracts sub-equal or the outer one slightly prolonged, thin and membranous, narrowly hyaline margined finely or sometimes obscurely nerved, narrow and attenuate, slender-pointed or sub-aristulate, or the inner one mucronate from a scarious apex, the outer one clasping for 2–3 mm. at base: interior scales about half the length of the bracts: flowers 5–9, pale-blue, very small; perianth appearing to be only about 6 mm. long, very delicate and faintly-nerved: capsules pale and thin-walled, 3–5 mm. high, on slender, somewhat flexuously-erect, exserted pedicels, 17–25 mm. long.

Southeastern Michigan, Birmingham, Oakland County, September 27, 1898, O. A. Farwell.

Very distinct from any species of the Eastern States, appearing to group more naturally with the fibrous-based *S. Floridanum* and allied species of the South.

Sisyrinchium strictum

About 30 cm. high in close tufts not fibrous-coated at base, pale, bright green and glaucous, keeping its color when dried, the spathes often purple and sometimes the entire plant purplish-tinged. Leaves over half the height of the stems, closely erect, rather thin, but firm and closely striate-nerved, 1–2 mm. wide, slenderly acute, the edges minutely serrulate to smooth; stems about 1.5 mm. wide, the wing-margins rather thin, mostly serrulate; node only one, bearing a slender erect bracteal-leaf, shorter or longer than the mostly two short, erect, approximate peduncles which are narrowly wing-margined with denticulate edges: spathes erect, narrowed into the peduncle, 16–20 mm. long, 1.5–3 mm. wide, the bracts subequal, but usually the inner one slightly surpassing the outer and obviously the broader above, acute or mucronulate, rather openly fine-nerved, almost carinate, the dorsal line of the outer bract usually showing a more or less abrupt descent into the acuminate apical part, the margins below slightly hyaline, united for about 5 mm. above the base; interior scales small, half the length of the bracts or less: flowers 3–6 on erect, slightly exserted pedicels 20–23 mm. long; perianth deep blue-purple, apparently about 10 mm. long; stamineal column about 5 mm. high; pedicels distinctly margined or even winged, the exserted tips becoming purple: a single capsule is truncate obovate, pale and thin-walled over 4 mm. high: seeds not quite mature, oblong, dark and rugulose-pitted, 1–1.25 mm. in longer diameter.

Vestaburg, Montcalm County, Michigan, collected by Professor C. F. Wheeler, June 22, 1898, "in sandy soil well in the southern limits of the white pine country."

Appearing somewhat intermediate between forms of *S. Atlanticum* and *S. mucronatum* Michx., but unmistakably distinct from either.

Sisyrinchium apiculatum

Loosely tufted from contractedly branched rootstocks and slender wiry roots, pale green and glaucescent not turning dark when dry, about 40 cm. high. Leaves loosely erect, apparently few and less than half the height of the stems, 1.5–2 mm. or more wide, acute, thin but firm, closely striate-nerved, very smooth-edged, somewhat withering-persistent and becoming loosely flexuous and fibrillose about the base of the tufts; stems erect, 1–2 mm. wide, narrowly winged; nodes mostly two, separated by an interval of 4–6 cm., the lower bearing a foliaceous erect bracteal-leaf and one or two peduncles often much surpassing the second node, which supports a short bracteal leaf and two or three peduncles; peduncles very slender, narrowly margined, smooth or finely denticulate, distinctly constricted at the base of the spathe, erect or divergent, those from the first node sometimes 8 cm. long, the upper ones shorter: spathes often deflected, short and relatively broad, 10–13 mm. long, 2–3 mm. wide, the bracts subequal, mostly incurved above, acute, or the inner one sometimes obtuse, prominently striate, broadly hyaline-margined, convex and sharp-edged, the inner one emerging rather abruptly above the clasping base (3–4 mm. long) of the outer one; interior scales rather broad and blunt, much shorter than the bracts, flowers about 6, blue, rather small; perianth about 8 mm. long; stamineal column about 4 mm. high; ovary glandular-puberulent: capsule dark, broadly subglobose, apiculate, sparsely puberulent, on loosely erect, distinctly margined pedicels, 13–17 mm. long.

Muskegon, Muskegon Co., Michigan, June, 1898, communicated by Professor W. J. Beal.

In appearance perhaps most suggestive of *S. Atlanticum*, but not at all that species.

Notes on Covillea and Fagonia

By Anna Murray Vail

Dr. B. L. Robinson (Syn. Fl. **1**: 356) has pointed out that the leaflets of *Larrea divaricata* Cav. are more narrowly oblong, more widely spreading and are less inclined to be falcate as well as more decidedly connate than are those of *Larrea Mexicana*. Mr. F. V. Coville recently (in litt.) also claims that however closely related, the southwestern species is distinct from the Chilian species. The plant on which I based my examination of *Larrea divaricata* was a duplicate of the "Macrae" specimen mentioned by Dr. Robinson and it is undoubtedly *L. Mexicana*. Since then I have seen the following specimens from South America (Herbarium of the British Museum) purporting to be *Larrea divaricata:* Lorenz, no. 105; Cordoba, G. Hieronymus, "5, 6, 1877"; South Am., Pearce; Chili, Bridges, 1843, and a specimen from Patagonia which is identical with one from Rio Negro, North Patagonia, from the Wilkes expedition in the Herbarium of Columbia University. They all agree with the differences referred to by Dr. Robinson and in addition I will add that they do not appear to be quite so resinous as the North American plant and the fine silky pubescence of the young leaves seems to be more abundant and to persist longer; the venation is also more distinct. There are some North American specimens, however, which approach very closely to *L. divaricata* and among them I noted one collected at "El Paso, New Mexico," by H. Carruthers, Nov. 10, 1884, in the Herbarium of the British Museum and a specimen without flowers or fruit collected by Frémont on his expedition to California in 1849 (Herb. Torrey).

The synonymy of these two species should therefore stand as follows:

Covillea divaricata (Cav.) Vail, Bull. Torr. Bot. Club, **22**: 229. 1895

Larrea divaricata Cav. Ann. Hist. Nat. **2**: 122. 1800. Cav. Ic. **6**: 40. *pl. 560, f. 1.* 1801.

Covillea tridentata (DC.)

Zygophyllum tridentatum Moç. & Sessé; DC. Prodr. **1**: 706. 1824; A. DC. Calques des Dess. *pl. 159*.

Larrea Mexicana Moric. Pl. Nouv. Am. 71. *pl. 48*. 1833–46.

Larrea glutinosa Engelm. Wisliz. Rep. 9. 1848.

Zygophyllum Californicum Torr. & Frém.; Frém. Rep. 257. 1845.

FAGONIA CALIFORNICA Benth. Bot. Sulp. 10. 1844.

A type specimen of *F. Californica* var. *Barclayana* Benth.* in the Herbarium of the British Museum is puberulous as described, but does not show the very marked and conspicuous gold-colored glands of *Fagonia Californica* var. *glutinosa* Vail (Bull. Torr. Bot. Club, **22**: 229). The species is very variable and it is doubtful whether any of the forms described deserve varietal rank.

COLUMBIA UNIVERSITY, May 19, 1899.

* Syn. Fl. **1**: 355.

Notes on Plants of the Chicago District

By E. J. Hill

In studying the flora of a restricted region, no matter how carefully it seems to have been explored, one is frequently surprised by finding new things. It almost seems as if such plants ought to be classed with those which are known to be introduced, like many migrants along the railways or escapes from gardens. But they are really old residents that had failed to be detected. No region can be regarded as thoroughly explored till every acre of its wild areas at least has been examined. Then some plants are so rare or local or grow under such peculiar conditions that a few square rods or even feet may comprise their range. This is said of the flowering plants and the vascular cryptogams. When we come to the lower orders of plants the space occupied by a given species may be still more restricted. I have in mind a single elm tree to a hollow knot of which I must go to get a little moss, *Anacamptodon splachnoides* Brid., though I do not suppose it is confined to that one knot of all the like hollows which may be found in the region traversed. But the problem is to find the other places, something I should value in its bearings on work pertaining to the geographical distribution of the mosses of the Chicago region. Yet eight years have passed without additions to that hollow space, fortunately so low down on the trunk as to be in easy reach of eye and hand. Bearing this in mind, together with the purpose of extending the range of some plants well known elsewhere, or more particularly indicating their presence here if within their general range as hitherto given, the following notes have been prepared. They are mostly plants detected in the Chicago area during the past two seasons, and such remarks are added as may serve to elucidate their character. The plants are also largely from the dune region at the south end of Lake Michigan, a tract with a remarkably varied flora, whose sand hills, hollows and swamps are an unfailing delight to botanists. They are arranged in groups the better to compare and indicate their range.

The most striking of these are such as have ascribed to them

an Atlantic coast range or occur eastward of the Alleghanies, extending in some cases along the coast to the southwest to Louisiana, Texas and Mexico. I have ceased to be surprised at this since first meeting with such plants in 1870 growing on the sandy terraces or the bordering wettish lands along the Kankakee river in Illinois. All of these have since been traced to the dune region of Lake Michigan, or have had their range extended to other parts. But some of them have not yet had intermediate stations recorded for them till the Atlantic slope is reached, like *Rynchospora cymosa*, *Eleocharis capitata* and *E. melanocarpa*, unless they occur inland farther to the south. To these may now be added *Panicum verrucosum* Muhl., *P. lanuginosum* Ell., *Scleria Torreyana* Walp., *Psilocarya nitens* Wood, *Xyris Caroliniana* Walt., with a range from Massachusetts or New Jersey south to Florida, or along the gulf to Louisiana and Texas, and, in the case of *S. Torreyana*, to Mexico. *Psilocarya scirpoides* Torr. occurs with *P. nitens* but has a more restricted range along the coast, "eastern Massachusetts and Rhode Island." Perhaps there should be added to these *Rynchospora macrostachya* Torr., which is made a variety of *R. corniculata* A. Gray and given the same range as the type in Britton and Brown's "Illustrated Flora," but in the older books is confined to the coast region. It is well marked, its long slender spikelets erect or but slightly spreading. It is remarkably abundant where it occurs, like grass in a meadow, and very striking with its prominent brown spikes. *Xyris Caroliniana* spreads over considerable areas making masses of yellow beds in the less grassy portions of desiccated or partially desiccated sloughs in the summer season. The two *Psilocaryae* are specially noteworthy, growing in company in the muddy borders of sloughs, usually in dense masses, so that a single handful will show specimens of both kinds, but so distinct that a little practice enables the eye to separate them without resort to a lens to examine their achenia, which is the final test. Though so close together it is hard to find a specimen that is intermediate in character or classed without difficulty with its appropriate type. I know few plants of any genus so intimately associated that maintain their characters so uniformly and so plainly show that they are specifically distinct. Though frequently intermingled in the same ground-bed they usually oc-

cupy in mass different areas whose borders overlap, *P. scirpoides* more abundant, taller and stouter. It is interesting to note also that the spikelets are often much changed in appearance by a rust, probably the same which Torrey mentions in the original description of *P. scirpoides* in his "Monograph of North American Cyperaceae."* "The flowers are frequently affected with a species of *Uredo*, insomuch that during one season Mr. Green [of New Bedford, Mass., who seems to have sent Torrey the first specimens of the plant] was unable to find a single specimen that was not diseased."

Fuirena squarrosa Michx. nearly ranks with this group, having one locality north of Detroit, Mich., accorded it, and occurring also in northern Ohio. West it appears again in Nebraska. Last summer it was found in a single locality in the dune region.

These plants generally grow in proximity in the same sloughs, being plants of wet ground, with the exception of *Panicum lanuginosum* which frequents the slopes of neighboring sand hills and comes down to the sloughs at their base. It occurs also in localities outside of the dunes proper. They have been obtained near Dune Park, Porter County, Ind., all but *Scleria Torreyana* in a section of the dune area I had not visited until 1897, and am not aware of its having been explored by others previously.

Some plants from the same section which have had an eastward or a southern range assigned them can be added to the list. *Eleocharis Robbinsii* Oakes, not given farther west than Clinton County in Central Michigan, the only known locality in the State (Beal and Wheeler's Michigan Flora, 1892); *Scleria reticularis* Michx. and *S. pauciflora* Muhl., south of this along our meridian. By finding the last the past season there are given to the dune region five of the six species of *Scleria* within the range of the Manual region, *S. triglomerata* and *S. verticillata* being known from here before and quite general in their occurrence. They can all be obtained in a limited area at Dune Park, together with the plants heretofore mentioned, and within a circle of scarcely more than a mile radius. To this group may be added *Panicum sphaerocarpon* Ell., a plant of dry sand hills; *Linum striatum* Walt., in open wet or wettish ground, both from Dune Park; *Cassia nictitans* L. from

*Ann. Lyc. N. Y. 3: 361. 1836.

the sand hills and ridges of Tolleston, Ind.; and *Aristida gracilis* Ell., from Pine near the lake shore. The latter grows in ground that can hardly be called dry, for it occurs in sand bordering sloughs dry at the time of flowering. Yet one can reach out and get *Utricularia cornuta* and *U. gibba* with one hand while taking the *Aristida* with the other, so that its spring or early summer condition must be quite moist or even wet. *Panicum flexile* and *P. pubescens* are grasses commonly growing with it showing the composite ecological character of the soil conditions often seen in the dune flora, baffling one sometimes to determine whether they are xerophytic or hydrophytic, since they are both at different times of the year. The wettish sands of the spring and early summer provide the seeds of these annual grasses with better means of germination than the drier ridges subject to the wind and where the vegetation is scantier, the ground more bare, so that they grow more abundantly and luxuriantly in ground that becomes dry and suits a xerophytic plant when near its maturity. The westward distribution of *Vitis Labrusca*, which was obtained in the dune region in 1897, was discussed at large in an article in the BULLETIN of the Torrey Botanical Club in October, 1897.

Among the drift hills near Mokena, south of Chicago, two *Carices* occur which have a southern range for this meridian, *C. Shortiana* Dewey, in wet meadows, and *C. triceps* Michx. in oak woods. The latter has a single station given it farther north in the central part of southern Michigan, and both range in Illinois from Peoria south. *Cyperus acuminatus* Torr. and Hook., a sedge with a southwestward extension, was found last year by the Desplaines River at Lockport, Ill. It has been known hitherto in the state as a plant of the valley of the Illinois River and towards the Mississippi. The three are still plants of the Illinois valley for our region as they are beyond the divide which separates the lake region from streams flowing toward the Mississippi.

Some plants with a general northern range or adapted to colder conditions have been added to our flora. *Carex oligosperma* Michx. comes into the dune region from the north, being found in sphagnous swamps and in cranberry marshes at Miller, Ind. The little bitter cress, *Cardamine parviflora* L., was obtained in the oak woods with *Carex triceps* though I have occasionally met

with it before. Perhaps there should be added to this northern list *Spiranthes latifolia* Torr., two specimens of which were found by Mrs. Agnes Chase of Chicago, growing on the bogs of springy ground near *Carex Shortiana*. I am not aware of its occurrence elsewhere in this state except in Menard County, a station farther south. In a pond in the same neighborhood an abundance of *Callitriche heterophylla* Pursh was secured, a plant of a wider range, mostly southward, but new to our region. Another rare plant was found twice by Mrs. Chase in the season of 1897, *Ophioglossum vulgatum* L., first in the damp, sandy borders of a slough at Miller, and again in the boggy border of Wolf Lake at Roby, Ind. I have seen it once before during the time of my botanical work, nearly forty years ago in western New York, where I also knew the Adder-tongue Fern in boyhood as a curious plant of the wet meadows. To meet with it twice after so long a time was a rare treat. It had been seen in Illinois so rarely that when Patterson published his "Catalogue of Illinois Plants" in 1876, but a single specimen was reported, obtained by Dr. Schneck in Wabash County.

Some plants have been recently added to our flora which are readily confounded with others that are similar and thus are easily overlooked. *Cyperus Houghtonii* Torr. does not greatly differ from some forms of *C. Schweinitzii* Torr., but is generally a lower plant with a more compact inflorescence, and may also, when the two are neighbors, grow higher up on the sand hills; it is also earlier by nearly a month. It has been in my herbarium since 1881 on the same sheet with its congener, collected in the dune region, but had failed to be separated, perhaps not without cause. In 1878, while studying the flora of Michigan at Petoskey and vicinity, a *Cyperus* was found on the sand hills at Indian River which I identified as *C. Houghtonii* from the description given in Torrey's Cyperaceae, as it was not in the Manual. To be better satisfied some were sent, together with *C. Schweinitzii*, to a well known botanist for verification. They were both pronounced *C. filiculmis* Vahl. This plant has been a familiar one for some time as well as *C. Schweinitzii*. I rested somewhat uneasily under the weight of authority, but finally concluded that *filiculmis* and *Schweinitzii* were different and *Houghtonii* might be a form of the latter, since it was not recognized in our handbooks. The Mich-

igan plant was quite remote from the place where those described by Torrey were obtained, "Lake of the Isles, Northwest Territory," but it has since been reported from the same locality by C. F. Wheeler, as well as from other parts of Michigan. Another of these plants is *Scirpus Smithii* A. Gray, quite closely resembling small forms of *S. debilis* Pursh. Both grow in the muddy borders of sloughs in the sand region, the former as yet seen only at Whiting, Ind. Growing with these, but of wider range, is *Juncus articulatus* L., which may be overlooked on account of its resemblance to *J. Richardsonii* Schult., a very common species here. *J. scirpoides* Lam. may be included with them, in general appearance like some forms of *J. Torreyi* Coville. It is not assigned to the west by Britton and Brown, but I have known it here since 1876 and have since identified it as collected at an earlier date at Kankakee, Ill.

Ledges of rock not being common in our area, plants which require or may seek such a habitat are not expected in much variety. Conditions of this kind exist to some extent along the Desplaines river from Lamont to Joliet, where the Niagara Limestone has been scarped out by glacial action, and low cliffs bordering the flood plain are formed with a talus of rocks at their base. The excavation of the Drainage Canal through this valley, requiring much rock cutting, may in time increase these conditions, for crevices above the waterline will be likely to furnish a foothold for such plants, as the rock faces of unused quarries now do. The most interesting plant of this kind is the little fern, *Pellaea atropurpurea*, which clings in abundance to the face of such a cliff at Lamont. *Silene antirrhina divaricata* Robinson grows with it, its slender sprawling habit making it look quite different from the upright and stiffer form common in dry ground especially by roadsides. I found it the second time the past season growing under somewhat different conditions on bluffs of clay which border a small stream near Thornton, south of this city, but of the same weak, sprawling character, its branches widely spreading. This adds two more stations in Illinois to the one already reported, Rockford. It was also found last season near Peoria. *Pentstemon pubescens* Solander is another denizen of the cliffs as well as of the thin soil spread over the rocks which form the glaciated floor of

the river valley. The cliff also furnishes me the only station for a pretty liverwort, *Grimaldia barbifrons* Bisch., its forking thallus forming little patches on the thin soil of crevices. *Polygonum exsertum* Small may be mentioned in this connection, like *Pentstemon pubescens* frequenting the rocky soil of the valley floor both here and at Lockport.

In the field of introduced plants novelties may continually be expected. It is well to note their arrival as nearly as possible, for the migration of plants becomes important in giving some idea of their habits and rate of spreading. As an example the Yellow Cress (*Nasturtium sylvestre*) may be cited. In 1890 it was found near Western Springs, west of Chicago. It had not been reported from our region before and seemed quite local, growing along the wet banks of Salt Creek and by roadsides and in neighboring meadows. Now it is exceedingly abundant along the Desplaines from Riverside to Lamont or beyond. Salt Creek enters the Desplaines near Riverside, and another stream, Flag Creek, heads near Western Springs, but a short distance from Salt Creek, and enters the Desplaines above Lamont. Either route makes an easy path for the spreading of such a plant, but its habits show that it is also provided with other means of migrating. It is a hardy plant and adapts itself to quite a range of conditions: it will grow with its stems half buried in mud and water, and seems equally at home by the roadside where the wagon wheels may bruise it. On railway embankments it spreads beside the rails and even roots in the ballast. Under these dryer conditions it is more branching and bushy, or it may be procumbent, leaning on the ground for support. The railways are in fact responsible for most of our introduced plants as well as their dispersion when once established. Some of these plants are weeds which could well be spared, others are harmless or may be desirable acquisitions.

Coming from the east may be mentioned *Bromus tectorum* L., small and softly hairy, which appears along the railroads east of the city in Indiana. It was first detected in 1897. At the same time *Centaurea Jacea* L. was obtained. *Reseda alba* L. was collected last year in the streets of Morgan Park south of the city. *Artemisia annua* L. was obtained the first time last season from roadsides at Lamont.

But most of our introduced plants came to us from the west or southwest. In 1897 *Agropyron glaucum* R. & S. was found well established in the dry sand at Clarke, Ind. Whether it would prove as troublesome as the real Couch-grass, *A. repens*, of which it is considered a variety by some, remains to be seen should it persist and spread. It was spreading thickly in soil where such grasses as *Stipa spartea*, *Calamagrostis longifolia*, *Eragrostis pectinacea*, *E. Purshii* and *Panicum virgatum* usually grow. Its subterranean stems did not seem as abundant or formidable as those of *A. repens*, but in richer cultivated fields might be different. As the Blue-joint or Blue-stem of the western stockman, highly praised when it is said of it that "no richer hay can be made from anything known," it might have value as a grass for sand dunes. *Helianthus petiolaris* Nutt., of the dry plains of the west, is becoming frequent by railroads both east and west of the city. It is quite ornamental along their roadbeds, blooming when but eight or ten inches high and rarely exceeding a couple of feet. *Allionia linearis* also comes from west of the Mississippi and was taken last summer from street sides at Morgan Park not far from the Rock Island railroad. In a ditch by the same railroad at South Englewood in the city is a patch of *Bidens involucrata* Britton, its large yellow flowers rather handsome. It comes into the western part of Illinois where it may be native, though its range is westward. It was not given in Patterson's catalogue in 1876 and plainly seems to be adventive here. *Coreopsis tinctoria* Nutt was likewise found in street-side lawns and parkways at Morgan Park, perhaps an escape from gardens, though it may have come by the same route as the *Allionia*, being indigenous to the same region. *Plantago aristata* Michx., a low plant with long, stout and prominent spikes, which are rather abundant, appears in the stiff blue clay taken out of the Drainage Canal and on railway embankments near by. It was doubtless discovered more than a century ago by Michaux "in *pratensibus Illinoensium*," in the autumn of 1795, when he travelled in the southern part of the state, though he makes no mention of the discovery in his journal. Dr. Mead reported it from the vicinity of Quincy, farther north than Michaux came. It is interesting to find that it has migrated to the neighborhood of this city, flourishing under somewhat different con-

ditions from those in prairies and meadows. *Aristida oligantha* Michx. was collected in the same place, a grass with about the same range in this state as the *Plantago aristata*. *Sporobolus neglectus* Nash appears like an introduced grass. I met with it first in 1895 by the Wabash railroad in Will county and again the past season at Lake Zurich, Lake county, where it grows by roadsides with *Panicum proliferum* and *Sporobolus vaginaeflorus*, a frequent grass in dry grounds and waste places where it generally grows in dense patches. Both of them have a different habit when growing by roadsides or in places where they are not crowded, forming stools with the much stouter stems semi-prostrate or ascending. *Panicum proliferum* has a similar habit, becoming a good sized weed in dry grounds, though smaller than in its native swamps or wet lands. The three seem well adapted to endure the wear and trampling to which such plants as grow by highways are more or less subjected.

New and interesting Plants from Western North America.—V

By A. A. Heller

Lepidium Idahoense sp. nov.

Apparently annual; stem 20–50 cm. high, smooth to the naked eye, but sparingly puberulent under a lense, somewhat shining, purplish below, much branched above, forming a corymbose top: basal leaves not seen; lower cauline obovate-oblong, about 6 cm. long, on margined petioles of 2 cm., laciniately dentate, the divisions ascending, sparingly covered on the margins and veins with whitish, curved bristles; upper cauline short-petioled or sessile, entire or nearly so, and finally reduced to linear bracts: inflorescence glabrous; pedicels slender, divaricate, or somewhat ascending, 4 mm. long; petals white, prominent, obovate cuneiform, slender clawed, about 2 mm. long; pods nearly orbicular, glabrous, 2 mm. or slightly more in diameter, notched; style very short, stout.

Our no. 3044, collected on the right bank of the Snake River, near Lewiston, Nez Perces County, Idaho, May 11, 1896, altitude about 800 feet. Later older and taller specimens were collected in gravelly ground along Hatwai creek, six miles east of Lewiston. The type is in my private herbarium.

To *Lepidium Idahoense* belongs no. 145 of Sandberg, MacDougal and Heller, collected along the Clearwater river, about eight miles east of Lewiston, in May, 1892. Their specimens were referred by Mr. Holzinger to *Lepidium alyssoides* A. Gray, a species with which it has no particular affinity.

Lepidium simile sp. nov.

Annual; stem 30–35 cm. high, strongly puberulent below, less so above, corymbosely branched above, basal leaves 3–4 cm. long, obovate-oblong, pinnately lobed or parted in the lower half, the upper almost entire, bluntish, puberulent; lower cauline leaves much like the basal but narrower and more acute; upper cauline entire or nearly so, lanceolate or linear lanceolate: inflorescence puberulent; pedicels slender, 3 mm. long, ascending; petals greenish-white, inconspicuous, spatulate, about 1 mm. long: pods about 2 mm. wide, a little longer than broad, slightly notched, puberulent, especially on the margins; stigma sessile or nearly so.

Our no. 3044a, collected on the right bank of the Snake River, near Lewiston, Nez Perces county, Idaho, May 11, 1896, altitude about 800 feet. This species was associated with *Lepidium Idahoense*, which it resembles in manner of growth and appearance of herbage. The principal differences are found in the inflorescence, as will be seen by comparing the two descriptions. *L. simile* is also less inclined to branch, and the branches ascending at an acuter angle. The type is in my private herbarium.

Ptelea rhombifolia sp. nov.

A shrub, about 2.5 meters high, branching above, the branches spreading, light brown, or grayish, the older ones usually smooth, those of the season's growth pubescent with short curved hairs; leaves trifoliolate, the petioles and lower surfaces covered with tomentose hairs, the upper surfaces also pubescent, but less so, and greener; petioles about 5 cm. long; leaflets somewhat rhombic ovate, or rhombic orbicular, the largest about 5 cm. long, and 4 cm. wide, their apices either rounded or slightly pointed, midrib yellowish, prominent, as are also the pinnate veins: inflorescence strongly pubescent, including the petals and the bases of the stamens; petals creamy white, obovate-oblong, about 4 mm. long; samara almost orbicular, about 1.4 cm. in diameter, reticulate.

My no. 1582, collected at San Antonio, Bexar county, Texas, April 27, 1894, altitude 600 feet. The specimens were collected in a wooded tract lying between the right bank of the river and the Southern Pacific railroad track. Specimens were distributed under the name "*Ptelea trifoliata mollis*," but can hardly be referred to that species, which has a more eastern distribution. The type is in my private herbarium.

To *Ptelea rhombifolia* I would also refer Dr. D. T. MacDougal's no. 139, collected in Walnut Cañon, near Flagstaff, Arizona, June 18, 1898.

Microsteris diffusa sp. nov.

Diffusely branched from the base, 15–25 cm. high, often 30 cm. broad, pubescent throughout with chaffy, spreading or twisted hairs, those on the upper portion of the plant glandular: leaves all sessile, the lowest ones oblong-oval, nearly glabrous, the others lanceolate, acute, usually about 4 cm. long, and from 5 mm. to 1 cm. wide; flowers rather numerous; calyx 1 cm. long, the tubular

portion united by a membrane, the lobes about 1 mm. wide at the base, gradually attenuate to the mucronate apex, erect in anthesis, spreading, and more or less recurved at maturity; corolla pale violet, the slender tube barely the length of the calyx, the lobes very small: seeds straw-color.

Our no. 3098, collected near the mouth of the Potlatch river, Nez Perces county, Idaho, May 20, 1896, altitude about 1200 feet. The plants grew in rich, stony basalt formation in a thinly wooded tract on the right bank of a small stream which empties into the Potlatch just above the junction of that stream with the Clearwater.

Our specimens were distributed either as "*Phlox gracilis*" or *Collomia gracilis*, and are near to that species in most particulars. The corolla lobes, however, are much smaller, the sepals broader at the base, and the seeds straw-color, instead of light brown, and it is of totally different habit, being more like *Microsteris humilis* in that respect. The type is in my private herbarium.

CASTILLEJA LUTEA Heller, Bull. Torr. Bot. Club, **25**: 268. 1898

In describing this species, I referred to its possible relationship with *C. desertorum* Geyer, and through oversight in reading Hooker's reference to this name, made the following inexcusable statement: "As he gives no description whatever, and does not even mention the color, which is said to be the sole difference, the name is *nomen nudum*, and we have no other clue than that of locality." The color is mentioned, however, for the bracts are described as yellow and scarlet variegated. I have now no doubt as to the distinctness of my species. In the herbarium of Columbia University there is now a single specimen besides my own *C. lutea* collected by Professor C. V. Piper of Pullman, Wash.

Crepis atrabarba sp. nov.

Perennial from an ascending rootstock; stems 4–5 dm. high, rather stout, covered with more or less deciduous wool, especially below, branched above: basal leaves lanceolate, about 20 cm. long, including the margined petiole, which is 5–6 cm. long, lower part of blade 5–6 cm. wide, deeply pinnately lobed or runcinately toothed, the divisions lanceolate or linear-lanceolate, some of them bearing slender teeth, the upper part of the blade forming a slender, linear-lanceolate, acuminate tip, 5–6 cm. long; cauline leaves usu-

ally of the same shape as the basal, but short-petioled, or the uppermost reduced to linear bracts: anthodia about ten, fastigiately corymbose: involucre 10–14 mm. long, wooly, the divisions linear, green whitish margins, costa not prominent, clothed with spreading, minutely glandular, black bristles; corollas evenly notched with five very short, blunt teeth; immature achenes light brown, apparently of almost even width; pappus longer than the achenes.

Our no. 3302, collected on the slope below Lake Waha, Nez Perces County, Idaho, June 22, 1896, altitude about 1800 feet. The plants were growing in rich, stony, basalt formation. In shape and cut of leaf, this species resembles *C. barbigera* Leiberg, but in no other respect. The type is in my private herbarium.

Grindelia Brownii sp. nov.

Perennial; stems clustered from a stout, ligneous root, 35–60 cm. high, slightly chaffy, red or purplish, branching above, leafy throughout: leaves sessile, spatulate-lanceolate, acute, the lower about 5 cm. long, and little more than 1 cm. wide at the widest part, serrate with spreading teeth; upper shorter and narrower in proportion, and often entire: heads 1 cm. high, and little broader; bracts of the involucre lanceolate or linear, the outer shorter and narrower, recurved; achenes short, obovate, truncate, several ribbed, two of these wing-like; pappus of two awns.

Our no. 3418, collected on the "breaks" of the Salmon River, near the mouth of Maloney Creek (about Forest on labels), Nez Perces County, Idaho, July 14, 1896, altitude about 2000 feet. The plants were growing on a precipitous grassy slope, in granite formation. Specimens were, perhaps, distributed without specific name, or as *Grindelia squarrosa*, under which species it can hardly be placed.

Named in honor of Mr. H. E. Brown, who acted as guide during the day on which the species was collected, and greatly assisted my wife and myself in our work. The type is in my private herbarium.

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Two new Polypodia from New Zealand

By Benjamin D. Gilbert

When the Transit-of-Venus expedition was sent to New Zealand, in 1874, the party landed at Dunedin, on the southeast coast of the middle island. But the fogs of that part of the island obscured the sky too much to suit an astronomer and after investigation it was decided to go inland about 100 miles to a place called Queenstown, on or near Waikatipu Lake, where the land was much higher and fogs did not exist.

Dr. C. H. F. Peters, who was the astronomer-in-chief, had promised me before leaving home that he would procure for me such ferns as he might be able to find. While his temporary observatory was being built he took many walks about the adjacent country; and during these rambles he picked up a considerable number of species that were really desirable. Among the *Lomarias* that abound there he secured *L. vulcanica*, *L. alpina*, *L. fluviatilis*, *L. Fraseri* and, of course, *L. procera*, and one of its most interesting varieties, *L. imbricata*. He brought two fine species of the beautiful *Todea* as well as endemic species of *Cyathea*, *Hymenophyllum*, *Trichomanes*, *Gleichenia*, *Dryopteris* and *Polypodium*. In this last genus there were specimens of a fern which Dr. Hooker does not give in his Flora of New Zealand and which has seldom been found in the southern hemisphere, viz., *Polypodium vulgare*. There is enough peculiarity about it to constitute a distinct variety, but if all the forms from different parts of the world that have been placed under this species really belong there, then this form also must be included.

There was also another Polypod allied to this, but so distinct that, after having it under occasional observation for 25 years, I have decided to describe it as an entirely new species. The description is as follows:

Polypodium viride sp. nov.

Rhizome the size of small whip cord, the growing end densely clothed with bright brown narrow-lanceolate scales, their filiform

apices often twisted: stipules slender, close together but hardly clustered, ¾ to 1¼ in. long, greenish or greenish-brown, naked, slightly margined at base: mature fronds 1¾ to 2½ in. long, ¾ to 1 in. wide, pinnate with a yellowish pellucid callosity in the sinus between pinnae: color bright green on upper side, paler beneath, rachis green with a few minute scattered scales as in *P. Plumula:* largest pinnae ½ in. long, strictly alternate, 8 to 9 pairs with a similar terminal pinna that is slightly pinnatifid below lower pinnae not reduced, each pinna expanded at base on both sides and adherent: veins free, *only once forked* semi-pellucid, clavate within the margin: sori in two rows, 4 to 6 on each side of costa and extending on to terminal pinna, chiefly on upper half of frond, large, borne at extremity of anterior branch of veins midway between costa and margin, but filling the entire width of pinna, papillose on upper side of frond: texture firm, subcoriaceous.

This beautiful little fern is intermediate between *P. pellucidum* and *P. vulgare.* It differs from its two allies in its smaller size, in having the veins only once forked like those of a *Cyathea*, in the fine black wavy costae, in the slender green stipes and rachis and in the metallic green color of its fronds. Although it is 25 years since it was gathered, it retains its greenness as brilliant as ever.

Polypodium vulgare auritum var. nov.

General features and venation same as in species: texture very thick and opaque, but veins raised enough to show venation: cut down close to rachis and lowest pair of pinnae fully separated: texture so thick that surface is corrugated and pitted on upper side, especially the ends of veinlets: edges of pinnae wavy: stipites very thick and stout but stramineous as in typical *P. vulgare*, lowest pair of pinnae generally auricled at base on lower side only, the auricle being sometimes one-third the length of pinna. These auricles are not always present even on fronds from the same root-stock, but they seem to be the rule and give a definite character to the variety. Our eastern *P. vulgare* stands midway between this and the thin sharp pointed form that grows in Japan and is known as var. *Japonicum.*

Acrostichum lomarioides Jenman*

By George E. Davenport

Attention having been called to this new species through Mr. Gilbert's recent revision of the Bermuda Ferns in the Bulletin of the Torrey Botanical Club for December, 1898, and Jenman having credited it to Florida, I venture to offer some comments upon it.

A. lomarioides is described in the Synoptical List of Jamaica Ferns, being published by G. S. Jenman in the Bulletin of the Botanical Department of Jamaica, and is said by him to have long been confused with *A. aureum* L., from which species he now separates it as distinct.

The basis for this separation rests primarily upon the following differences as described by Jenman himself—the greater size of the new fern, a greater difference in the relative size of the fertile and sterile fronds; the uniformly separate barren and fertile fronds —all the pinnae of the one being barren, and all of the other fertile; the much more sessile leaflets (turned transversely with the rachis, the plane to the sky like the blades of a step ladder); the intestiniform translucent, pale colored corpuscles covering the sporangia, which give a pale pruinose color to the soriferous under surfaces, and, according to Gilbert, a difference in the meshes of the venation, and the direction of the areoles.

None of these characters, however, seem to me to have specific value, and the greater number of them are more or less unimportant, as they constitute only such varying characters of a secondary nature as are found in a great many other ferns.

The force of Jenman's statement that the new fern is greater in size than the old one is neutralized by his own descriptions, which give the fronds of *A. aureum* as being "2 to 4 ft. tall, 1 to 1½ ft. wide"; and those of *A. lomarioides* as being only "2 to 4 ft. tall, but 1½ to 2 ft. wide," a difference in the breadth only, surely a character of no consequence whatever.

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* Read before the New England Botanical Club, March 3, 1899.

Mr. Gilbert describes his Bermuda plants as "being magnificent in size, reaching far above the head of any man, sometimes to the height of eight or nine feet." But J. Donnell Smith found plants of *A. aureum* in Florida growing to the height of eleven feet.

Pteris aquilina ordinarily averages from two to four feet in height, yet in Florida it has been known to reach the height of twelve and fourteen feet.

As for the uniformly fertile and sterile fronds, here again the force of Jenman's description of "all the pinnae of the one being barren, and all of the other fertile," is neutralized by his unfortunate citation of Professor Eaton's figure in Ferns of North America **2**: *pl. 58*, for an illustration, as that figure does not represent a frond with all of the pinnae fertile, but one with only the upper half fertile, as in normal *A. aureum*.

I do not wish to be understood as calling in question the validity of Jenman's species so far as it relates to his Jamaica plants, which I have not seen, and if there should exist a form there with uniformly dimorphous fronds in the same sense as we have them in *Onoclea*, *Osmunda*, and some other genera—with the tissue of the lamina transformed into sporangiferous receptacles, as, for example, in *Acrostichum* (*Polybotrya*) *apiifolium*—it would be entitled to recognition, but no such fern has as yet been recorded from Florida.

Contribution to a Knowledge of the Myxogasters of Maine.—III

By F. L. Harvey

Since my last article on the Myxogasters of Maine in this journal, February, 1897, specimens have been collected by Mr. E. D. Merrill, my assistant, and myself, which extend considerably the list of Maine species. They are recorded below together with new localities for species reported in previous contributions. Monmouth, where Mr. Merrill's specimens were taken, is on a tributary of Lake Cobbosseccontee, the location of one of the fish hatcheries of Maine. We have followed Lister in the order of presentation so far as possible. Numbers above 115 are accessions to the State list. Those below refer to species mentioned in previous articles. We are under obligations to Mr. A. P. Morgan, who has kindly given his opinion on specimens submitted to him.

116. *Physarum leucopus* Link.

Monmouth, July, 1897 (E. D. Merrill). This species is rare in America. Lister in his Mycetozoa gives Ohio as the only American locality. To find it so far east is interesting. The plasmodia were small but typical. Found on grass and blackberry leaves on the ground.

117. *P. citrinum* Schum.

Oldtown, 1898. Growing on a charred log at Kukunsook landing, Pushaw Lake (Harvey). Specimens in fine development. This is *Cytidium citrinum* Morgan. (Myx. M. V.)

118. *P. tenerum* Rex.

Orono, Me., 1898 (Harvey). This is the *P. obrasseum* B. & C. of Morgan's papers (Myx. M. V.). Specimens scanty and poor.

119. *P. compactum* Lister.

Birch log on moss, Oldtown, Me., August, 1898 (Harvey). This was found in woods on the border of Pushaw Lake at the Kukunsook landing. This is *Tilmadoche compactum* Wingate.

120. *P. psittacinum* Ditmar.

Monmouth, July, 1897 (Merrill). This is *Leocarpus psittacinum* in Morgan's Myx. M. V. Our specimens are fine.

121. *P. viride* Pers. var. *aurantiacum.*

On decaying pine logs, Orono, 1897 (Harvey). This is *Physarum aureum* Pers. On weathering, this form loses its orange color and then cannot be distinguished from *P. nutans,* the stalks of both species being always alike.

122. *P. albipes* Link.

Orono, 1897 (Harvey). We sent a specimen to Mr. Morgan who says: "Rostafinski included this species in *Tilmadoche nutans.* The stipe is long as in *Physarum nutans,* but the base is not umbilicate." The capillitium is like that of *P. leucophaeum* Fr. and I should prefer to label your specimen as you have it rather than *P. nutans* Pers.

123. *P. leucophaeum violaceus* Rost.

Orono, 1896 (Harvey). Mr. Morgan says: "Your specimen is very beautiful; sporangia almost destitute of lime and scarcely any in the capillitium. It is Rostafinski's var. *violaceus.* You seem to have all the forms of this species in Maine."

124. *P. Columbinum obovatum* A. & S.

Orono, Me., 1896 (Harvey). Mr. Morgan made the following note on specimens sent him: "This is a puzzle. Lister would promptly refer it to *Lamproderma physarioides* A. & S., but it is not what I understand to be that species, which is perfectly globose and has a silvery sheen. I should call it *Physarum Columbinum obovatum* in the Conspectus of A. & S."

11. *P. sinuosum* Fr.

Monmouth, Me., July, 1897 (Merrill). In fine development. This is *P. bivalve* Pers. in Lister's Monograph.

17. *Fuligo rufa* Pers.

Monmouth, Me., July, 1897 (Merrill). These specimens have a grayish fragile cortex and appear different from ordinary forms of *Fuligo septica.* Mr. Morgan named the specimens and we do

not know whether the *F. rufa* of his writings is regarded by him as different from *F. septica*. If the same, it has been reported from Maine, no. 17. If not, it should be added.

20. *Chondrioderma testaceum* (Rost.) Versuch.

Monmouth, Me., July, 1897 (Merrill). A single small specimen.

125. *Chondrioderma reticulatum* Rost.

Monmouth, Me., July, 1897 (Merrill). Abundant on fallen leaves.

23. *Diachea elegans* Fries.

Monmouth, Me., July, 1897. Mr. Morgan calls this *D. leucopoda* Rost. Cooke and Lister referred it to the above.

34. *Stemonitis microspora* Lister.

Monmouth, Me., July, 1897 (Merrill). This is *S. ferruginea* Ehr. but not of Fries. An abundant species in Maine maturing early.

37. *Comatriche aequalis* Peck.

Oldtown, Pushaw Lake. Abundant in August on charred logs (Harvey). Lister includes this under *C. obtusata*. Mr. Morgan thinks it rather resembles *S. typhoides* Rost. If *S. obtusata*, then it was reported as no. 37.

126. *Lamproderma arcyrionema* Rost.

Orono, Me., 1897 (Harvey). On rotten wood. Mr. Morgan says regarding my specimens, "I have no doubt this is *Stemonitis obtusata* Fr. S. M. and I am surer yet that it is *Stemonitis reticulata* Trentepohl.

127. *Lindbladia effusa simplex* Rex.

Orono, 1897 (Harvey). Monmouth, July, 1897. Mr. Merrill's specimen was nearly three inches across. The Orono specimen less than an inch. This is Peck's *Licea caespitosa* = Morgan's *Tubulina caespitosa*. The plasmodium of this is olive black,

128. *Cribraria argillacea* Pers.

Monmouth, Me., July, 1897 (Merrill). Growing in moss on the ground.

129. *C. aurantiaca* Schrader.

Bradley, Me., 1898 (Harvey). On rotten wood. Our specimens are *C. vulgaris* Schrad., which Lister refers to the above.

130. *Arcyria irregularis* Racib.

Orono, Me., 1896 (Harvey). Mr. Morgan says "these specimens puzzled me greatly. It is possible I have overlooked it in previous specimens, confounding it with *Hemiarcyria stipata* Schw. This I am confident Lister has done, which accounts for his *A. stipata*. There is the appearance of something abnormal about it, but the capillitium and spores appear all right. I can see no spirals on the threads; they are thickly set with prominences or blunt spines in some places. The threads do not appear to be attached to the wall but arise out of the stipe. I think it is an *Arcyria*. I cannot refer it to *Hemiarcyria stipata* Schw. though superficially it looks like it. *A. irregularis* Racib. describes it very well."

Arcyria minor Schw.

An abundant species in Maine was always referred to *A. incarnata* Pers. by Dr. Rex. Mr. Morgan thinks *A. affinis* Rost. the same thing, and that is the same as *A. vermicularis* Schum. an older name that should be restored.

131. *Lycogala repletum* Morgan.

Pea Cove, October, 1898, (Harvey). A single cluster of several specimens varying in size from a half inch to an inch and a half. Growing on a live elm about a foot from the ground in the edge of a hollow in the tree. This is a larger species than *L. flavo-fuscum* and the tubules are branches of broad flat membranes, instead of cylindrical outgrowths directly from the walls. The type specimens were collected by Mr. Parish in California. It is remarkable to find the species so far east.

Mr. Morgan says that "I am disposed to think this form equal to *Lycogala testaceum* (Wallr.), described in Flora Germanica." This is referred to *Lycogala flavo-fuscum* in Saccardo, but is probably distinct.

132. *Fuligo laevis* Pers. Pea Cove, Oct. 1898, F. L. Harvey.

A specimen sent Mr. Morgan was named as above. There is

great confusion in this group, several apparently distinct forms being referred to *Fuligo varians*. Mr. Morgan says of our specimens, "I have a specimen just like yours from Iowa, collected by McBride. The sporangial walls are greatly developed and persistent, the capillitium extremely scanty, the bladder-like vesicles being about all there is of it."

Remarks: We collected *Arcyria punicea* and *Physarum leucophaeum* on Mt. Ktaadn, in September, 1898, the former in the south basin at an altitude of 2,500 feet, and the latter on the edge of the plateau 3,500 feet. The sporangia of the latter were dwarfed. At Foxcroft we found *Ceratiomyxa mucida* in fine development.

A Bryological Memorial Meeting at Columbus, Ohio.

Columbus was the home for many years of William S. Sullivant and Leo Lesquereux, two names which will always awaken love and reverence from all students of North American mosses and hepatics. It is twenty-six years since Sullivant died, and this last quarter of the century has seen a marked extension of the limits of bryological study and a large increase in the number of students. It seems a fitting time and place to take a survey of the field, review the past and make plans for the future, hence it is proposed to make the coming meeting of the American Association for the Advancement of Science, which is to be held at Columbus, the occasion for a Memorial Day in honor of the Nestors in American Byrology and to call on all botanists and botanical journals to help make the occasion a memorable success. It is proposed to present a series of papers, illustrated by photographs, specimens and microscopical exhibits under the following topics: Historical papers and collections illustrating the bryological work of Hedwig, Palisot de Beauvois, Michaux, Muhlenberg, Bridel, Torrey, Drummond, Hooker and Wilson, Greville, Sullivant and Lesquereux, James and Watson, Austin, Ravenel, Wolle, Bolander, Eaton and Faxon, and Müller. Supplementing these there will be shown collections of specimens, macroscopic and microscopic, illustrating the monographic work of recent American students.

If foreign students who have worked on North American byrophytes can be persuaded to coöperate with us, the following will be asked to contribute: Bescherelle, Brotherus, Cardot, Dixon, Kindberg, Mitten, Pearson, Röll, Stephani, and Warnstorf.

An effort will be made to secure the loan of type specimens and illustrations from the following sources: Academy of Natural Sciences of Philadelphia, Academy of Sciences of New York, Columbia University, Geological and Natural History Survey of Canada, Harvard University, National Museum, Ohio State University, University of Wisconsin, and Yale University, as well as from private herbaria and collections. It is also requested that any portraits, autograph letters and type specimens and drawings

of special interest be loaned for the occasion, as well as presentation copies of books and pamphlets.

The following committee of organization will gladly answer any questions and give assistance to those wishing to contribute:

Mrs. N. L. Britton, New York Botanical Garden.
Professor W. A. Kellerman, Ohio State University.
Dr. George G. Kennedy, Readville, Mass.
Professor Charles R. Barnes, University of Chicago.
Professor Lucien M. Underwood, Columbia University.

Proceedings of the Club

DECEMBER 13, 1898.*

Vice-President Allen in the chair, thirty-five persons present.

Three new members were elected; two new nominations for membership were made: Mrs. Horace See, 50 W. 9th Street, and Ex-Chief Justice Charles P. Daly.

The paper of the evening was by Miss Marie L. Sanial on Nature Study in the Public Schools. The following is an abstract:

"The introduction of nature study in the lower grades of the public school is a new departure in elementary education. Of course, it is not intended to teach natural history as a science to children of a tender age. The purpose in view is simply to draw from nature certain object lessons calculated to aid in the orderly development of the perceptive and reasoning faculties. The method of instruction should rest upon two fundamental principles fully established by the observed facts of psychology. One is the fascinating power of visible motion upon the child's mind. The second, intimately connected with the first, is the natural process of mental development. This process, consisting as it does in observation and comparison, is essentially analytical and is, therefore, the very reverse of the constructive or synthetical process of nature herself. While nature proceeds in her work from the low and apparently motionless forms to gradually higher ones gifted with increasing powers of displacement, the human mind proceeds in its observation from the highest and most active to the lowest and most passive. The first object lesson should, therefore, be taken from the animal world and from those plants which, by their bright colors, rapid development and other striking features, are most suggestive of motion. If her material be taken from the vegetable world, for instance, the teacher should make such use of it or devise such artifices as will enable the pupils to see, follow and observe "the plant in action," so that their interest may steadily increase as they successively and spontaneously

* Omitted by mistake from its proper sequence in the last number.

discover that the apparently lifeless thing before them actually feeds, drinks and breathes, grows and moves, feels and acts, likes and dislikes, enjoys and suffers, lives and dies.

"In the examination of parts the following order, when practicable, will best conform with our fundamental principles: 1. The fruit; 2. The flower; both presenting qualities of color, form, taste and smell, which, together or singly, first commend them to the child's attention on the threshold of plant life investigation; qualities which correspond in some respect to the phenomena of visible motion in animal life.

"Descending by degrees from these upper and last products of vegetable development, will be observed in succession, the leaf, the stem and last the root.

"In other words we must begin with facts of a primary order, tending to develop attention, perception and observation. These first facts, simple and detached, apparently unrelated, will of themselves lead to the observation of other facts, more complex, more and more intertwined and at last obviously related; that is, facts of a higher order, tending to the exercise of judgment by comparison and consequent classification. When we shall have reached this point, our minds will be ready for the discovery, by induction, of still higher facts, imperceptible to our senses without the powerful aid of human reason, fully developed; we shall be ready for generalization. The whole philosophy of nature study—and we may say the whole philosophy of teaching—lies in the observance of this order.

"It is essentially the work of the teacher, who has reached the point of developed reason, to classify her facts, so that her pupils may without feeling her hand or her influence, be made to look for just such facts as are suited to their own intellectual stage. Not so much on the variety or brilliancy of her illustrations, as upon the natural, logical order in which she will imperceptibly compel their observation of facts will depend her success."

Miss Sanial added also an account of her experience as supervisor of nature study in the vacation schools of New York City, and indicated the difficulty at present confronting the subject on account of lack of provision for supply of material.

Miss Sanial's paper was followed by an extended discussion of

the needs of further provision for nature study in the public schools, participated in by Mr. Hyatt, Mr. Wade, Mr. Conroy, Mrs. Britton, the secretary and others, and followed by the adoption of the following resolution offered by Dr. Britton :

Resolved, That a committee of five members be appointed by the chair to prepare a presentation of the desirability of a systematic supply of nature study material to the public schools for submittal to the President of the Board of Education after approval by the club.

Miss Sanial exhibited an interesting series of mounts and cards showing the admirable work done in nature study in the vacation schools.

A large collection of photographs of wild flowers was exhibited by Mrs. Britton, displayed upon the wall facing the club. These photographs, the work of Mr. Henry Trott, of Philadelphia, are excellent for school or other illustrations. Mrs. Britton also commented upon the good beginnings made in New York and Brooklyn in hanging nature pictures in schools.

WEDNESDAY EVENING, MARCH 29, 1899.

Meeting held in the large hall of the College of Pharmacy.

Dr. Rusby in the chair. 60 present.

Four new members were elected : Hr. W. H. Lewis, Jr., 11 East 35th Street, nominated by Dr. H. H. Rusby ; Miss Marion Shutes, 168 West 120th street, nominated by Miss Marie L. Sanial ; Miss Elizabeth Anne Jacobs (Public School 117), 117 E. 82d Street ; Miss Nellie Geraty (Public School 96), 39 E. 76th Street.

Dr. Britton reported as chairman of committee on nature study, that finding it impracticable to get the members of the committee together to call on the President of the Board of Education, he had transmitted the committee's report to President Little by mail. The report of the committee was accepted and the committee discharged.

The first paper was by Professor Francis E. Lloyd, on the Functions of the Suspensor, and was illustrated by drawings and by a series of microscopes exhibiting slides.

Mr. Lloyd described the structure of the suspensor typical of the genera *Galium*, *Asperula*, *Vaillantia*, etc., and showed that haustoria are formed which absorb food from the endosperm. The large basal cell of *Capsella* was shown also to possess a function quite similar, because, as the preparations showed, the basal cell destroys the tissue of the inner integument in its vicinity and thus becomes embedded in it.

The second paper was by Mrs. E. G. Britton, on the Ferns of the Eastern United States, illustrated by the stereopticon.

Mrs. Britton exhibited mounted specimens of all the rarer ferns of the Eastern States, many of them of her own collection, giving the range of each species. She also exhibited lantern slides made from photographs of these ferns taken as they grow. Those of the maiden-hair, hart's tongue and beech-fern were taken from the fernery in the New York Botanical Garden; five of them were views from the Catskill Mountains taken by Mr. Van Brunt; Mr. Hulst contributed one from Lake George, and Mr. Lorenz five from Willoughby Lake, Vermont. Others were Adirondack views taken by Stoddard. Mrs. Britton stated that she would continue to fill in the omissions where she had not been able to obtain photographs, and hoped to complete her collection in the future. She expressed the hope that as the interest in ferns increases the love of them would likewise grow, and that the rarer ones would not be exterminated by useless transplanting to locations where they will not survive. It was stated that thus far Rutland County, Vermont, shows the greatest number of ferns of any of the Eastern States, having 42 species and ten varieties. There are seldom more than 20 species in any locality, unless there should be a great variety of soil and habitat as at Jamesville, N. Y., where Prof. Underwood has found 34 species. Long Island has 25, and Staten Island 23 species.

In further illustration, the Torrey Club collection of ferns and many sheets from the Columbia collection, were exhibited, and a series of photographs from Professor Atkinson, showing the variations produced by cultivation of *Onoclea sensibilis*.

An exhibit to illustrate *Onoclea sensibilis* in the fossil state was also furnished by Dr. Hollick, the same being of special interest as the only living species which is actually found fossil.

Mr. Wm. A. Lorenz, of Hartford, Conn., was introduced by Dr. Rusby as one who had collected 34 species of ferns about Willoughby Lake, Vermont. Mr. Lorenz described the lake and neighboring cliffs with the illustration of lantern slides, and spoke of the hundreds of plants of *Woodsia glabella* flourishing there close together, fruiting at 1 inch or at 6 inches. In the sunshine it becomes more leathery as if passing into *W. hyperborea.* Mr. Lorenz also finds *Dryopteris spinulosa dilatata* reverting there to the type of the species.

Mr. W. N. Clute exhibited several fronds of *Dryopteris simulata,* collected by him at Babylon, L. I., last summer, and pointed out a distinction from *D. Thelypteris* in the fact that each pinna of *D. simulata* is not of uniform breadth but broader near the middle; it fruits chiefly in the shade, and *D. Thelypteris* in the sun.

Dr. Rusby spoke of the beauty of the ferns on the mountain slopes near Plainfield, N. J., and at localities near there for *Asplenium ebenoides, Cystopteris fragilis,* and *Cheilanthes lanosa.*

Mr. Clute remarked that he had collected 16 species of ferns within a mile of Fort Lee, and 59 species are now growing at the Botanical Garden.

Adjournment followed.

EDWARD S. BURGESS,
Secretary.

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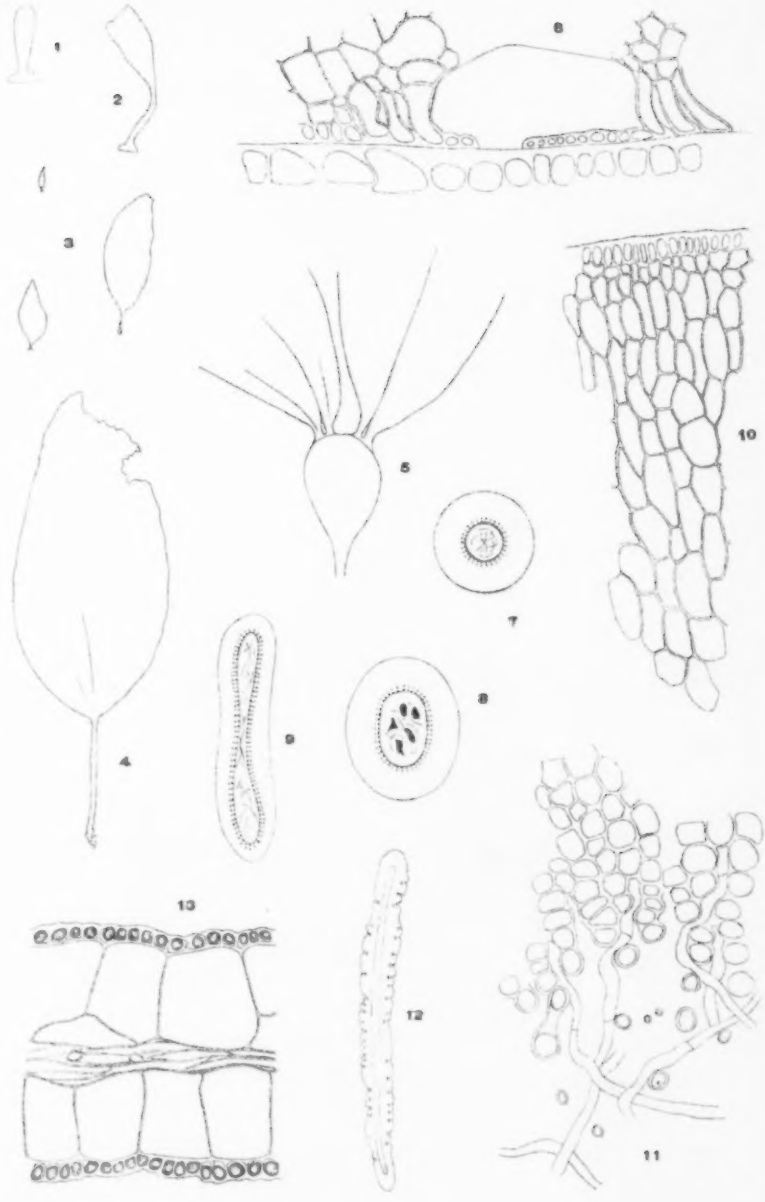

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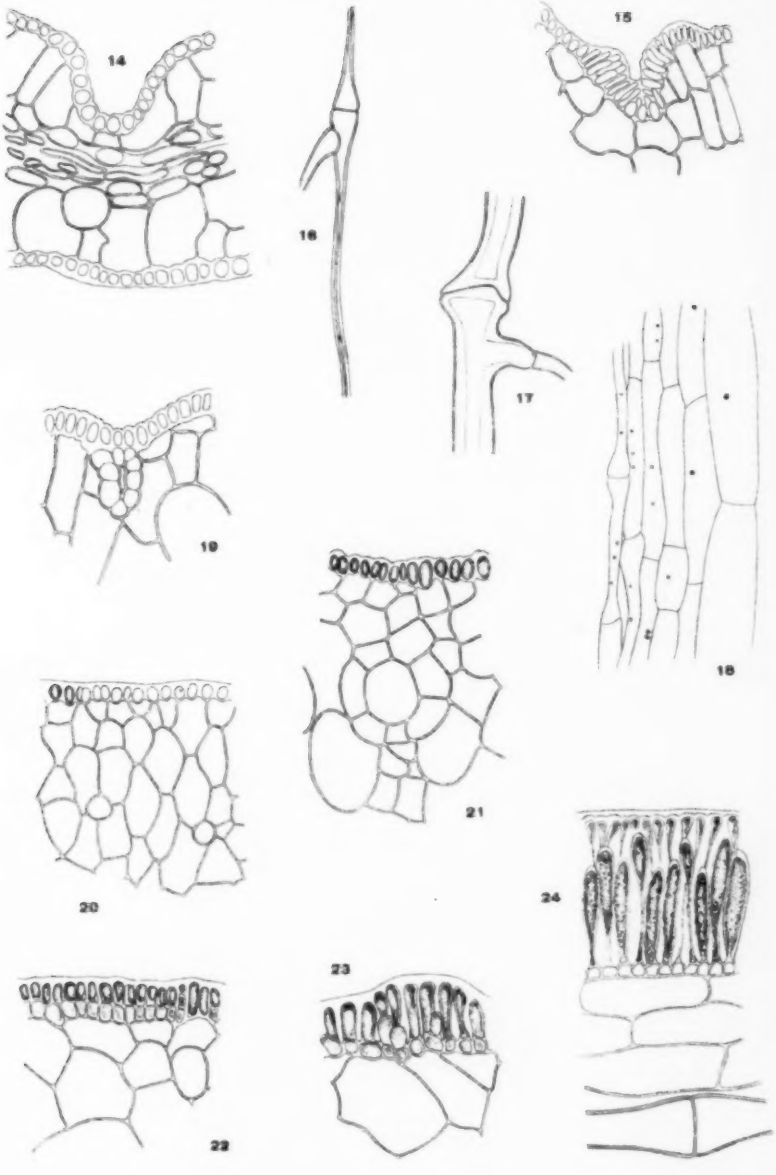

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